AD-761 215

MODIFICATION AND CONTROL OF OXIDE STRUCTURES ON METALS AND ALLOYS: (PHASE III)

Robert C. Svedberg

Westinghouse Electric Corporation

Prepared for:

Naval Air Systems Command

February 1973

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

WANL-M-FR-73-003
FEBRUARY 1973

Westinghouse Astronuclear Laboratory

MODIFICATION AND CONTROL OF OXIDE STRUCTURES ON METALS AND ALLOYS: (PHASE III)

FINAL REPORT

(20 DECEMBER 1971 - 20 JANUARY 1973)

"APPROVED FOR PUBLIC RELEASE-DISTRIBUTION UNLIMITED"

BY
R. C. SVEDBERG

PREPARED UNDER CONTRACT N00019-72-C-0132

FOR

NAVAL AIR SYSTEMS COMMAND
DEPARTMENT OF THE NAVY
WASHINGTON, D. C. 20360
ATTN: I. MACHLIN
NASC-AIR 52031 B

WESTINGHOUSE ELECTRIC CORPORATION - P. O. BOX 10864 - PITTSBURGH, PENNSYLVANIA 15236

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)

Westinghouse Astronuclear Laboratory
P. O. Box 10864
Pittsburgh, Pennsylvania 15236

2a. REPORT SECURITY CLASSIFICATION

Unclassified

2b. GROUP

N/A

3. REPORT TITLE

Modification and Control of Oxide Structures on Metals and Alloys: (Phase III)

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final Technical Report - 20 December 1971 to 20 January 1973

5. AUTHOR(S) (First name, middle initial, last name)

Robert C. Svedberg

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
March, 1973	~~201~~ 198	30

8a. CONTRACT OR GRANT NO.

N00019-72-C-0132

b. PROJECT NO.

c.

d.

9a. ORIGINATOR'S REPORT NUMBER(S)

WANL-M-FR-73-003

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT

Approved for Public Release - Distribution Unlimited

11. SUPPLEMENTARY NOTES

Details of illustrations in this document may be better studied on microfiche

12. SPONSORING MILITARY ACTIVITY

Naval Air Systems Command
Washington, D. C. 20360

13. ABSTRACT

The rutile structure family for oxide compounds of the type $Nb(B)O_4$ where B = Cr, Al, or Fe have been identified as being the primary oxide phase in the scales formed on oxidation resistant Nb intermetallic compounds and Nb-Ti-Cr-Al, Nb-Fe-Al, Nb-Cr-Al-Co, and Nb-Cr-Al-Ni alloys. Along with this oxide, small amounts of either $(B)_2O_3$ where B = Cr, Al, or Fe or a $CoAl_2O_4$ spinel in cobalt containing alloys were detected. Oxygen transport rates through Nb_2O_3-Cr_2O_3, Nb_2O_5-TiO_2, Nb_2O_5-ZrO_2, and Nb_2O_5-Al_2O_3 were also determined using thermogravimetric techniques. Of the oxide compounds evaluated, only oxygen transport through Nb_2O_5-Cr_2O_3 was slow enough to warrant its classification as a protective scale. In addition to oxidation rate data, metallographic studies and electron microprobe studies are reported for the Nb intermetallic compounds and alloys.

DD FORM 1473 1 NOV 65 (PAGE 1)

S/N 0101-807-6811

iq

UNCLASSIFIED

Security Classification

A-31408

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Oxide						
Defect Structure						
Oxygen Diffusion Coefficient						
Niobates						
Niobium Alloy Oxidation						
Oxygen Transport in Niobates						

INSTRUCTIONS

1. ORIGINATING ACTIVITY: Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization *(corporate author)* issuing the report.

2*a*. REPORT SECURITY CLASSIFICATION: Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2*b*. GROUP: Automatic downgrading is specified in DoD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. REPORT TITLE: Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis immediately following the title.

4. DESCRIPTIVE NOTES: If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. AUTHOR(S): Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. REPORT DATE: Enter the date of the report as day, month, year; or month, year. If more than one date appears on the report, use date of publication.

7*a*. TOTAL NUMBER OF PAGES: The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7*b*. NUMBER OF REFERENCES: Enter the total number of references cited in the report.

8*a*. CONTRACT OR GRANT NUMBER: If appropriate, enter the applicable number of the contract or grant under which the report was written.

8*b*, 8*c*, & 8*d*. PROJECT NUMBER: Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9*a*. ORIGINATOR'S REPORT NUMBER(S): Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9*b*. OTHER REPORT NUMBER(S): If the report has been assigned any other report numbers *(either by the originator or by the sponsor)*, also enter this number(s).

10. AVAILABILITY/LIMITATION NOTICES: Enter any limitations on further dissemination of the report, other than those imposed by security classification, using standard statements such as:

(1) "Qualified requesters may obtain copies of this report from DDC."

(2) "Foreign announcement and dissemination of this report by DDC is not authorized."

(3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through
____________________________________ ."

(4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through
____________________________________ ."

(5) "All distribution of this report is controlled. Qualified DDC users shall request through
____________________________________ ."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. SUPPLEMENTARY NOTES: Use for additional explanatory notes.

12. SPONSORING MILITARY ACTIVITY: Enter the name of the departmental project office or laboratory sponsoring *(paying for)* the research and development. Include address.

13. ABSTRACT: Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as *(TS)*, *(S)*, *(C)*, or *(U)*.

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic [illegible] may be used as key words but will be followed by [illegible] indication of technical context. The assignment of links, rules, and weights is optional.

1b

FOREWORD

The work described herein was performed at the Astronuclear Laboratory of the Westinghouse Electric Corporation under Navy Contract N00019-72-C-0132. This report is a continuation of the work started under Navy Contracts N00019-70-C-0148 and N00019-71-C-0089. Mr. I. Machlin of the Naval Air Systems Command served as Project Manager. Program supervision at WANL was by Mr. R. W. Buckman, Jr., Manager, Materials Science.

The author wishes to acknowledge additional personnel contributing to this program. These are Messrs. S. S. Laciak for metallography, R. W. Conlin, x-ray and microprobe studies, and C. S. Fitterer, heat treating and general assistance.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Continued)

LIST OF ILLUSTRATIONS (Continued)

LIST OF ILLUSTRATIONS (Continued)

LIST OF TABLES

DEFINITION OF TERMS

$\tilde{D}$	=	Chemical Diffusion Coefficient (cm^2/sec)
t	=	Time (sec)
Q	=	Total weight loss between two equilibration conditions (grams)
A	=	Cross sectional area (cm^2)
k_p	=	Parabolic rate constant (mg^2/cm^4-min)
T	=	Temperature (^oC)
Φ	=	Pilling-Bedworth Ratio
l	=	1/2 thickness of oxide (cm)
X	=	Diffusion distance (cm)
P_{O_2}	=	Partial pressure of oxygen (atm)
C	=	Concentration ($grams/cm^3$)
$M(t)$	=	Weight loss at any time t (grams)
$\tilde{D}_P$	=	Chemical diffusion coefficient derived for the condition $\tilde{D}t/l^2 \leq .25$ using a parabolic model (cm^2/sec)
$\tilde{D}_L$	=	Chemical diffusion coefficient derived for the condition $\tilde{D}t/l^2 \geq 0.15$ using a logarithmic solution (cm^2/sec)

1.0 INTRODUCTION AND SUMMARY

The rutile structure family for oxide compounds of the type $Nb(B)O_4$ where B = Cr, Al, or Fe have been identified as constituting the oxide scale formed on oxidation resistant Nb intermetallic compounds and Nb-Ti-Cr-Al, Nb-Fe-Al, Nb-Cr-Al-Co, and Nb-Cr-Al-Ni alloys. In some cases a hematite structure family oxide B_2O_3 has also been identified along with the rutile oxide product. In the alloy containing cobalt, a $CoAl_2O_4$ spinel was identified. Metallographic, x-ray diffraction, and electron-microprobe studies were used to examine these oxide structures. Oxygen transport measurements through mixed binary niobates have shown that the Nb_2O_5-Cr_2O_3 system exhibits the slowest rate of oxygen diffusion of the oxides tested thus far.

This study, initiated under Contract No. N00019-70-C-0148[1] and continued under Contract No. N00019-71-C-0089[2], is being made to investigate the feasibility of modifying oxide defect structures to enhance oxidation protection of elevated temperature structural materials. The approach of this program is considered rather unique since prior research and development programs have generally attempted to increase oxidation resistance of a base alloy by either adding additional alloying elements to the basic structural material or by coating the basic structural material with an oxidation resistant material. However, alloying to obtain oxidation resistance can cause a degradation in mechanical strength and ductility of the base structural material while coating to obtain oxidation resistance requires the introduction of a foreign compound which must adhere to, but not react with, the structural substrate.

In contrast, this study has investigated various techniques designed to modify the defect structure of the equilibrium oxides which are characteristic of the parent structural material and in this way attempt to improve oxidation resistance without either changing the structural and mechanical properties of the substrate or adding additional components to the system.

Several of the techniques, which have been investigated thus far, are pre-oxidation treatments and modification of oxide defect structures by application of high pressures.

The Phase I[1] study has shown that high pressure high temperature exposure of Nb_2O_5 does produce a denser phase that maintains its characteristics after quenching to room temperature. However, it has not yet been possible to investigate the stability of the quenched phases nor the transport properties of the quenched phases. In addition, it has been demonstrated that a pre-exposure of alloy B-1 (Cb-15Ti-10W-10Ta-2Hf-3Al) in 20 torr oxygen at 650°C results in a decrease in the oxidation rate in air at 1040°C when compared to untreated B-1 alloys. This is the second method of pre-treatment shown to be effective in decreasing the rate of oxidation of the B-1 alloy. The first reported treatment involved an oxidation exposure of 2400°F in air for 1 hour which improved the oxidation during exposure to 2200°F air[2]. These experiments showed that changing the oxide structure is possible. The maximum potential of these various techniques has yet to be demonstrated.

Results from Phase II [2] indicate that mixed oxides of Nb_2O_5 - TiO_2, and Nb_2O_5-HfO_2 would not form protective oxide layers based on limiting the transport of oxygen through the scale and protecting the parent metal. The NiO-Nb_2O_5 binary oxides exhibited a stoichiometric behavior, i.e., no weight loss as a function of oxygen pressure, until a partial pressure equivalent to that of the dissociation pressure of NiO is reached. At that point, a reduction reaction apparently begins, and large weight losses begin.

The work reported herein includes (1) a continuation of the oxygen transport rate measurements in binary niobates Nb_2O_5-TiO_2, Nb_2O_5-Al_2O_3, Nb_2O_5-ZrO_2, and Nb_2O_5-Cr_2O_3 utilizing a new flow regime where the gases are introduced at the bottom of the reaction tube and exit through the balance chamber and arc melted oxide samples in place of pressed and sintered oxides. Only the Cr_2O_3-Nb_2O_5 system exhibited low oxygen transport properties, indicating that this rutile oxide is the best oxidation barrier of all the systems

and compositions tested thus far. However, because of the lack of data defining phase relationships as a function of composition, temperature, and oxygen pressure, it is not yet possible to determine the optimum conditions required to minimize oxygen transport in this system.

(2) An investigation of the oxide behavior of the Nb_3Al, $NbAl_2$, $NbAl_3$, $NbCr_2$, $NbFe_2$, $NbCo_2$, and NbNi intermetallic compounds. The oxidation kinetics, photomicrographs of the oxide scales, identification of the oxide phases by x-ray powder diffraction studies of the oxide scale, and the results of microprobe studies for these intermetallics are presented. The intermetallic compounds $NbAl_3$, $NbCr_2$, and $NbFe_2$ exhibited low oxidation rates in air. For these three intermetallic compounds, the rutile structure $NbBO_4$ and the hematite structure B_2O_3 where B = Fe, Al, Cr were found to constitute the oxide scale. Parabolic rate constants of between .018 - .31 $mg^2/cm^4/min$ were determined from the oxidation rate data for these systems. $NbCo_2$ formed a liquid phase oxide at 1200°C. The other intermetallics formed either Nb_2O_5, columbite $NiNb_2O_6$, Al_2O_3-$9Nb_2O_5$, or Al_2O_3-$25Nb_2O_5$ oxides mixed in with the rutile structure.

(3) The oxidation behavior of the Solar J and Solar B-IV alloys is described utilizing metallographic, electron beam microprobe, and x-ray diffraction techniques. The enhanced oxidation resistance of the Solar J alloy over the Solar B-IV alloy was shown to be caused by increased chromium content of the J alloy which stabilized a rutile type $NbCrO_4$ oxide scale. When the chromium was reduced from 9 to 4 weight per cent, a Nb_2O_5-TiO_2 oxide phase was detected in the scale formed on the alloy along with the rutile $NbCrO_4$ phase causing oxygen transport through the scale to increase.

(4) The oxidation behavior of the five alloys Nb-Al-Cr-Co, Nb-Al-Cr-Ni, Nb-Fe-Al, and Nb-Ti-Fe-B was characterized by powder x-ray, electron beam microprobe, and metallographic techniques after oxidation at 1200°C. The best system from this group of alloys was the system Nb-Al-Cr-Co where a $CoAl_2O_4$ spinel was formed in the oxidation product along with the rutile $NbAlO_4$-$NbCrO_4$. The parabolic oxidation constant at 1200°C in air ranged between .045 to .323 $mg^2/cm^4/min$ for all systems except Nb-Ti-Fe-B. However, only for Nb-Al-Cr-Co did the parabolic rate constant decrease with time.

2.0 OXYGEN DIFFUSION THROUGH MIXED NIOBATES

2.1 THERMOGRAVIMETRIC TECHNIQUES FOR DETERMINING THE OXYGEN DIFFUSION COEFFICIENT

Oxidation-reduction kinetics and nonstoichiometry of metal oxides have been studied primarily by thermogravimetric[3-9] and electrical conductivity techniques[10-14]. To date, nearly all of the published kinetic data for nonstoichiometric oxides utilizing thermogravimetric techniques have involved oxides in which the predominant defect was the singly ionized cation vacancy. This work involves oxides whose structure is thought to be contained on the anion lattice in the form of single or double charged anion vacancies.

In these studies, the driving force for diffusion is provided by the partial pressure of oxygen established in the gaseous phase adjacent to the oxide. By equilibrating the oxide with a known oxygen partial pressure and then abruptly changing the oxygen partial pressure, the time rate of weight change indicates the mobility of oxygen thru the lattice as it is being removed from or diffused into the sample. By assuming that the surface of the specimen equilibrates immediately with the surrounding atmosphere, the chemical diffusion coefficient $\tilde{D}$ can be obtained, once the geometry of the sample is established, from an integrated solution of Fick's second law assuming a constant diffusion coefficient.

The rationale for sample geometry selection has been reported previously[2].

2.2 SOLUTIONS TO FICK'S SECOND LAW

Chemical diffusion is used to denote diffusion which is the result of a concentration or chemical potential gradient. This is not to be confused with self-diffusion or tracer diffusion, which does not occur as the result of a chemical potential or concentration gradient. After Wagner[15]

$$\tilde{D}_i^s = \lim_{(\partial c_i/\partial x) \to 0} \left[\frac{Ji}{(\partial c_i/\partial x)} \right] c_i \qquad (1)$$

$\tilde{D}_i^s$ = self-diffusion coefficient

J_i = flux

x = distance

c = concentration

The self-diffusion coefficient on the ith species, $\tilde{D}_i^s$, is proportional to the diffusion coefficient for the defect responsible for the migration of the ith species. The chemical diffusion coefficient $\tilde{D}$ is the proportionality constant in Fick's Law

$$J = \tilde{D} \ (d\tilde{c}/dx) \qquad (2)$$

Using the integrated thin plate solution for Fick's second law

$$\frac{\partial c}{\partial t} = - \tilde{D} \frac{\partial^2 c}{\partial x^2} \qquad (3)$$

after Crank[19]

$$\frac{M(t)}{Q} = 1 - \sum_{n=0}^{\infty} \frac{8}{(2n+1)^2 \pi^2} \left\{ e^{-\tilde{D}(2n+1)^2 \pi^2 t/4l^2} \right\} \qquad (4)$$

where t = times (seconds)

l = half thickness of the plate.

For values of $\tilde{D}t/l^2 \geq 0.15$ only the first term (n=0) of the series is required, therefore equation (4) simplifies to

$$\frac{M(t)}{Q} = 1 - \frac{8}{\pi^2} \left(e^{-\tilde{D}\pi^2 t/4l^2} \right) \qquad (5)$$

or

$$\log(1 - M(t)/Q) = \log \frac{8}{\pi^2} + \frac{\tilde{D}\pi^2 t}{(9.2) l^2} \qquad (6)$$

By plotting log (1 - M(t)/Q) vs t, the slope of the line can be measured, and $\tilde{D}$ can be calculated.

For $\frac{\tilde{D}t}{l^2} \leq 0.25$ the following relationship can be used to evaluate $\tilde{D}$.

$$\left(\frac{M(t)}{A}\right)^2 = k_p \bullet t \qquad (7)$$

and

$$k_p = \frac{4\tilde{D}}{\pi} (\Delta c)^2 \qquad (8)$$

where Δc is the oxygen concentration gradient across the oxide during reaction or oxidation in grams/cc.

2.3 EXPERIMENTAL MATERIALS

Two kinds of samples were used for evaluation of the oxygen transport rate. The Nb_2O_5-TiO_2 sample was made from pressed and sintered powders as previously described[(2)]. The samples of Nb_2O_5-Cr_2O_3, Nb_2O_5-Al_2O_3, and Nb_2O_5-ZrO_2 were made by arc melting the partially sintered oxides in a tungsten electrode inert gas arc melting furnace. The sample was contained in a water cooled copper crucible. The as-melted samples are shown in Figure 1.

To overcome the formation of voids or piping in the samples, the arc-melter was powered by an adjustable DC welding power supply which was used to enable the operator to taper the power to zero and retain a molten pool so the oxide would solidify directionally with no voids. The arc melted oxides were ground into a flat disk configuration.

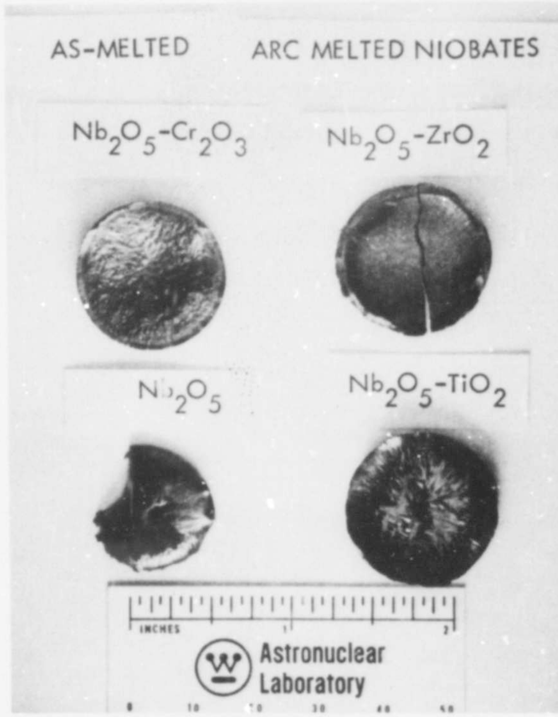


FIGURE 1

Arc-Melted Niobates in As-Melted Condition

2.4 EXPERIMENTAL APPARATUS

The experimental apparatus has been described previously with one exception. Figure 2 shows the new position of the gas outlet for the gas flow regime finally selected.

Analyses of the results obtained during Phase II[3] have indicated that a change in gas flow through the microbalance system was required. As reported in Phase II, the gas flow entered at the bottom of the reaction tube and exited above the furnace but before entering the microbalance chamber. This flow system was tried initially to eliminate flowing hot gases into the microbalance chamber. However, weight changes with a blank nonreactive sample indicated that the slow diffusional mixing of gas in the balance chamber took an unnecessarily long and unpredictable length of time to achieve a constant value. As these results for the nonreactive sample had to be subtracted from the reactive sample to get a true oxygen weight loss, this process sometimes took longer than was necessary to achieve equilibrium in the reactive sample.

Nonreactive samples of Al_2O_3 were evaluated to determine the effects of two alternate flow conditions. In Condition I, the gases were admitted into the balance chamber and exited at the bottom of the furnace. This enabled the gases to mix initially in the balance chamber and then flow past the sample. Condition II involved flowing the gases into the system at the bottom and exiting through the balance chamber. TiO_2-Nb_2O_5 was studied utilizing Condition I.

Condition II was selected to be used for the remainder of the runs. It was discovered that Condition I created a situation where the gas composition at the sample changed gradually as the gases mixed in the balance system. Condition II enabled both the objections to Condition I and the regime selected in Phase II to be overcome. The gas front reached the sample quickly, and the mixing time of gases in the balance chamber was minimized.

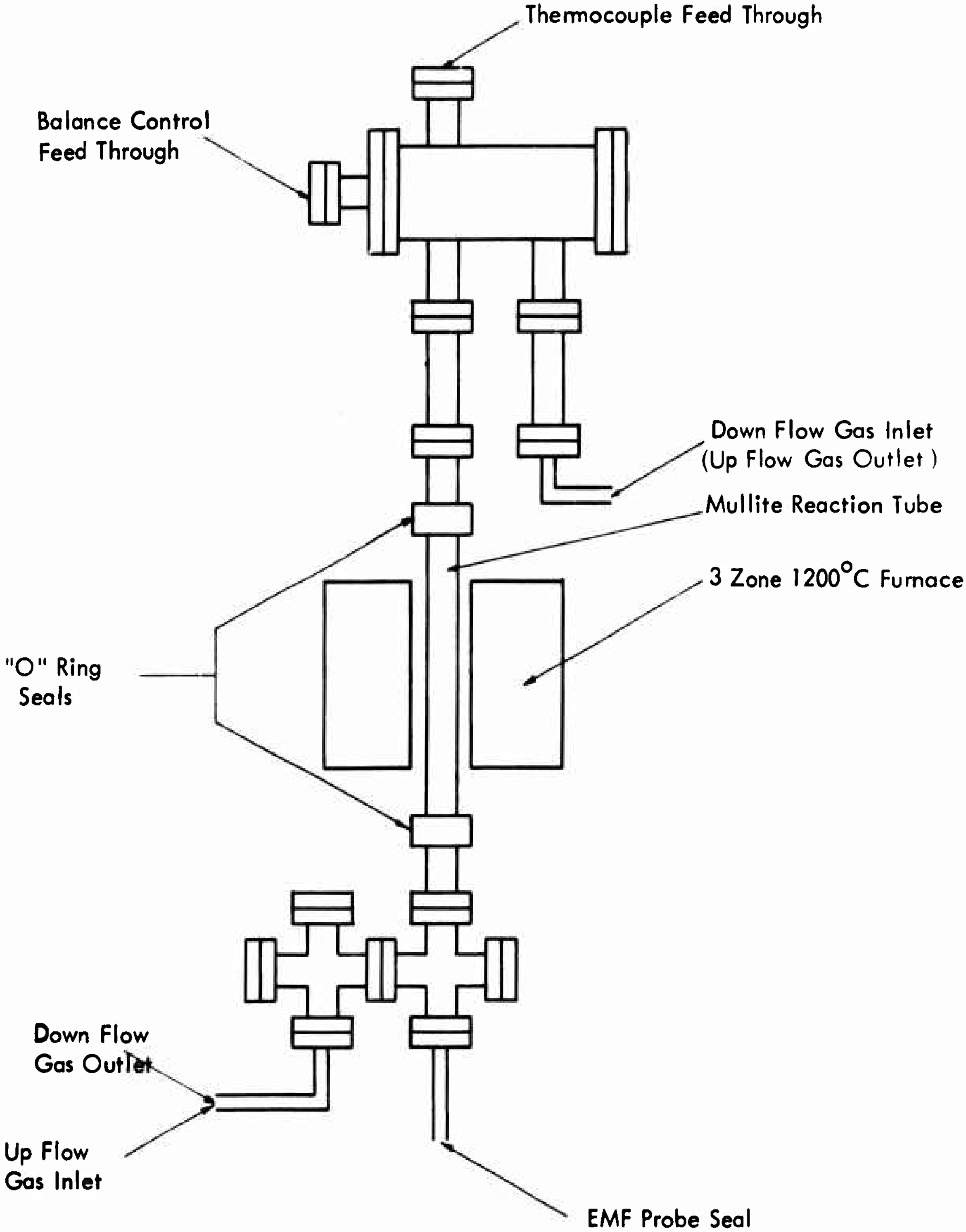


Figure 2. Schematic of Modified Vacuum Microbalance Used for Flowing Gas Studies

2.5 EXPERIMENTAL RESULTS

Table 1 presents a summary of the experimental results for all of the oxygen diffusion experiments. The results for TiO_2-Nb_2O_5 were taken with the reaction gases flowing down the reaction tube. The remainder of the systems were tested with reaction gases flow up the reaction tube. The biggest difference between these two techniques is the length of time for the reaction front of a newly established gas mixture to reach the sample and the severity of this front. In addition, Cr_2O_3-Nb_2O_5, Al_2O_3-Nb_2O_5, and ZrO_2-Nb_2O_5 were arc melted while TiO_2-Nb_2O_5 was pressed and sintered from oxide powders.

Listed in Table I are the chemical diffusion coefficients $\tilde{D}_L$ determined by taking the slope of log (1-M(t)/Q) vs time for $\tilde{D}t/l^2 \geq 0.15$ and the chemical diffusion coefficient $\tilde{D}_P$ determined by taking the slope of $(M(T)/A)^2$ vs time for $\tilde{D}t/l^2 \leq 0.25$. Also listed on Table 1 are the cumulative deviations from stoichiometry, the initial and final oxygen pressures between which the equilibration was carried out, and the time limits of the two diffusion models used. Oxygen weight loss as a function of time and oxygen partial pressure difference are plotted in Figures 3-14. Although the weight losses are shown on the graphs for each partial pressure starting at zero, the total weight loss for a given temperature and oxide system is cumulative.

A computer code was devised to calculate all data used to determine the diffusion coefficients. This data is contained in the Appendix.

Results for the chemical diffusion coefficient of oxygen as a function of system and temperature are summarized in Figure 15. All values of the chemical diffusion coefficient determined for each temperature and oxygen partial pressure range are shown by the length of the respective line. The primary purpose of the diffusion work was to determine which niobates had the lowest oxygen chemical diffusion coefficient and under which conditions of temperature and

Table 1. Chemical Diffusion Coefficients for Oxygen in Binary Niobates

System Mole Ratio	$\tilde{D}_L$ (10^{-7} cm^2/sec) $\frac{Dt}{l^2} > 0.15$	$\tilde{D}_P$ (10^{-7} cm^2/sec) $\frac{Dt}{l^2} < 0.25$	Dev. from Stoich-iometry Mg. of Oxygen	Dev. from Stoich-iometry Moles of Oxygen(X)	$Log_{10}(X)$	Initial Equil. Oxygen Pressure (atm.)	Final Equil. Oxygen Pressure (atm.)	$Log_{10}P$ Final Equil.	Temp. (°C)	Parabolic Model Upper Time Limit (sec)	Logarithmic Model Lower Time Limit (sec)
Cr_2O_3:Nb_2O_5	0.607	2.8	.740	.00729	-2.13	4.7×10^{-2}	7.18×10^{-15}	-14.144	850	31,037	18,600
	0.889	0.699, 1.04	1.416	.01396	-1.855	7.18×10^{-15}	4.42×10^{-17}	-16.355	850	21,192	12,700
	0.230, 0.328	0.063, 0.131	5.412	.05330	-1.273	4.42×10^{17}	4.25×10^{-18}	-17.372	850	81,913; 40,368	49,147; 34,463
1.67:1.00 $Cr_{3.34}Nb_2O_{10.01}$	0.340	5.27	3.440	.0339	-1.470	5.7×10^{-2}	3.17×10^{-11}	-10.499	1000	55,412	33,247
	0.145	1.58	15.716	.155	-0.810	3.17×10^{-11}	4.70×10^{-14}	-13.328	1000	129,931	77,958
	0 230	0.127, 0.624	37.516	.36978	-0.432	4.70×10^{-14}	1.33×10^{-16}	-16.872	1000	81,913	49,147
	0.680	1.07	4.736	.0467	-1.331	3.4×10^{-2}	7.017×10^{-9}	- 8.154	1175	27,705	16,623
	0.300	0.428	20.612	.2031	-0.692	7.017×10^{-9}	2.52×10^{-11}	-10.599	1175	62,800	37,680
	0.623	0.038	64.412	.6350	-0.197	2.52×10^{-11}	1.46×10^{-13}	-12.836	1175	28,024	16,814
ZrO_2:Nb_2O_5	2.36	1.46	1.208	.0140	-1.854	5.7×10^{-2}	1.95×10^{-14}	-13.710	850	21,806	8,086
	0.83	2.48	3.306	.0383	-1.416	1.95×10^{-14}	3.88×10^{-17}	-16.411	850	12,787	22,952
	1.23	1.14	6.262	.0724	-1.140	3.88×10^{-17}	2.11×10^{-19}	-18.676	850	27,974	16,918
2.85:1.00 $Zr_{2.85}Nb_2O_{10.70}$	3.04	1.83	0.968	.0112	-1.95	4.8×10^{-2}	1.71×10^{-11}	-10.767	1000	17,378	6,264
	0.542	1.94	3.032	.0351	-1.45	1.71×10^{-11}	3.73×10^{-14}	-13.428	1000	16,391	34,762
	4.12	1.49	6.220	.07185	-1.14	3.73×10^{-14}	1.97×10^{-16}	-15.706	1000	21,256	4,622
	7.52	12.1, 27.3	0.954	.011037	-1.957	5.6×10^{-2}	7.02×10^{-9}	- 8.154	1175	2,630; 1,165	2,532
	5.54	12.40	2.766	.0304	-1.494	7.02×10^{-9}	1.06×10^{-11}	-10.975	1175	2,562	3,437
	0.869	1.985	11.422	.1322	-0.879	1.06×10^{-11}	8.64×10^{-14}	-13.063	1175	15,994	21,900
Al_2O_3:Nb_2O_5	2 69	11.8	1.840	.0196	-1.709	4.6×10^{-2}	2.04×10^{-14}	-13.690	850	3,000	7,870
	2.05	11.3	3.508	.0373	-1.429	2.04×10^{-14}	3.85×10^{-17}	-16.415	850	3,135	10,322
	1.70	4.93	5.692	.0737	-1.133	3.85×10^{-17}	2.33×10^{-19}	-18.633	850	7,160	19,785
2.71:1.00 $Al_{5.42}Nb_2O_{13.13}$	2.62	18.4	1.548	.0165	-1.783	4.10×10^{-2}	8.35×10^{-12}	-11.078	1000	1,922	8,093
	7 59	17.8	2.736	.0294	-1.531	8.35×10^{-12}	3.09×10^{-14}	-13.510	1000	1,983	2,787
	2.3	6.7	5.334	.0568	-1.246	3.09×10^{-14}	2.18×10^{-16}	-15.662	1000	5,261	9,032
	3.49	16.0	0.960	.01021	-1.991	4.7×10^{-2}	7.26×10^{-9}	- 8.139	1175	2,223	6,066
	17 60	4.9	2.300	.0245	-1.610	7.26×10^{-9}	1.25×10^{-11}	-10.903	1175	7,188	1,205
	2.51	3.4	4.548	.0483	-1.316	1.25×10^{-11}	1.24×10^{-13}	-12.907	1175	10,390	8,421
TiO_2:Nb_2O_5	1.38	2.53	0.712	.00723	-2.14	5.0×10^{-2}	2.49×10^{-14}	-13.604	850	9,034	9,933
	1.33	0.662, 2.18	1.682	.0171	-1.77	2.49×10^{-14}	3.35×10^{-17}	-16.475	850	34,512; 10,480	10,307
	1.07	0.9	2.738	.0278	-1.556	9.38×10^{-18}	1.98×10^{-19}	-18.703	850	25,386	12,812
1.67:1.00 $Ti_{1.67}Nb_2O_{8.34}$	1.03	0.974, 3.9	2.688	.0273	-1.564	4.6×10^{-2}	1.54×10^{-11}	-10.812	1000	23,457; 5,858	13,309
	1.01	1.986	5.602	.0569	-1.245	1.54×10^{-11}	3.36×10^{-14}	-13.474	1000	11,504	13,572
	1.31	5.240	4.044	.0452	-1.345	3.4×10^{-2}	1.93×10^{-11}	-10.714	1000	4,359	10,465
	1.14	3.33	13 784	.1401	-0.854	1.93×10^{-11}	2.76×10^{-14}	-13.559	1000	6,861	12,025
	2.68	3.156; 8 45	81.470	.827	-0.0822	2.76×10^{-14}	1.68×10^{-16}	-15.775	1000	7,239; 2,704	5,232
	7.35*	2.32; 6.11	57.972	.239	-0.622	1.68×10^{-16}	2.66×10^{-14}	-13.575	1000	9,848; 3,739	1,865
	1.33	1.47	6.400	.065	-1.187	4.0×10^{-2}	7.98×10^{-9}	- 8.098	1175	15,543	10,309
	2.03	2.86	26.684	.271	-0.566	7.98×10^{-9}	1.75×10^{-11}	-10.757	1175	7,988	6,753
	33.30	0.781	94.374	959	-0.018	1.75×10^{-11}	8.26×10^{-14}	-13.093	1175	29,254	4,154

* Weight gain equilibrium

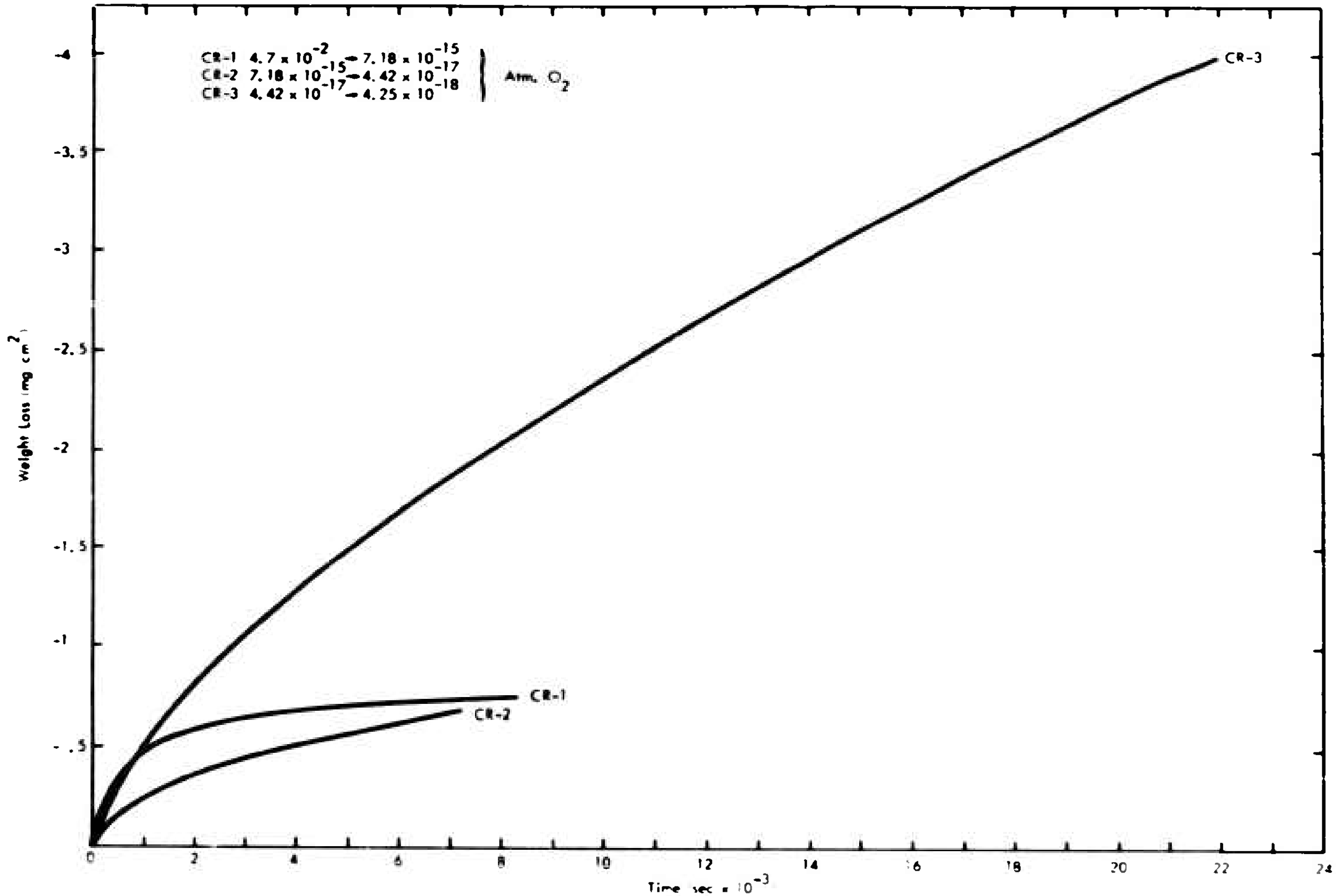


Figure 3. Weight Loss for 1.67:1.00 Molar Ratio Cr_2O_3-Nb_2C_5 as a Function of Time for Various Oxygen Partial Pressure Differentials at 850°C

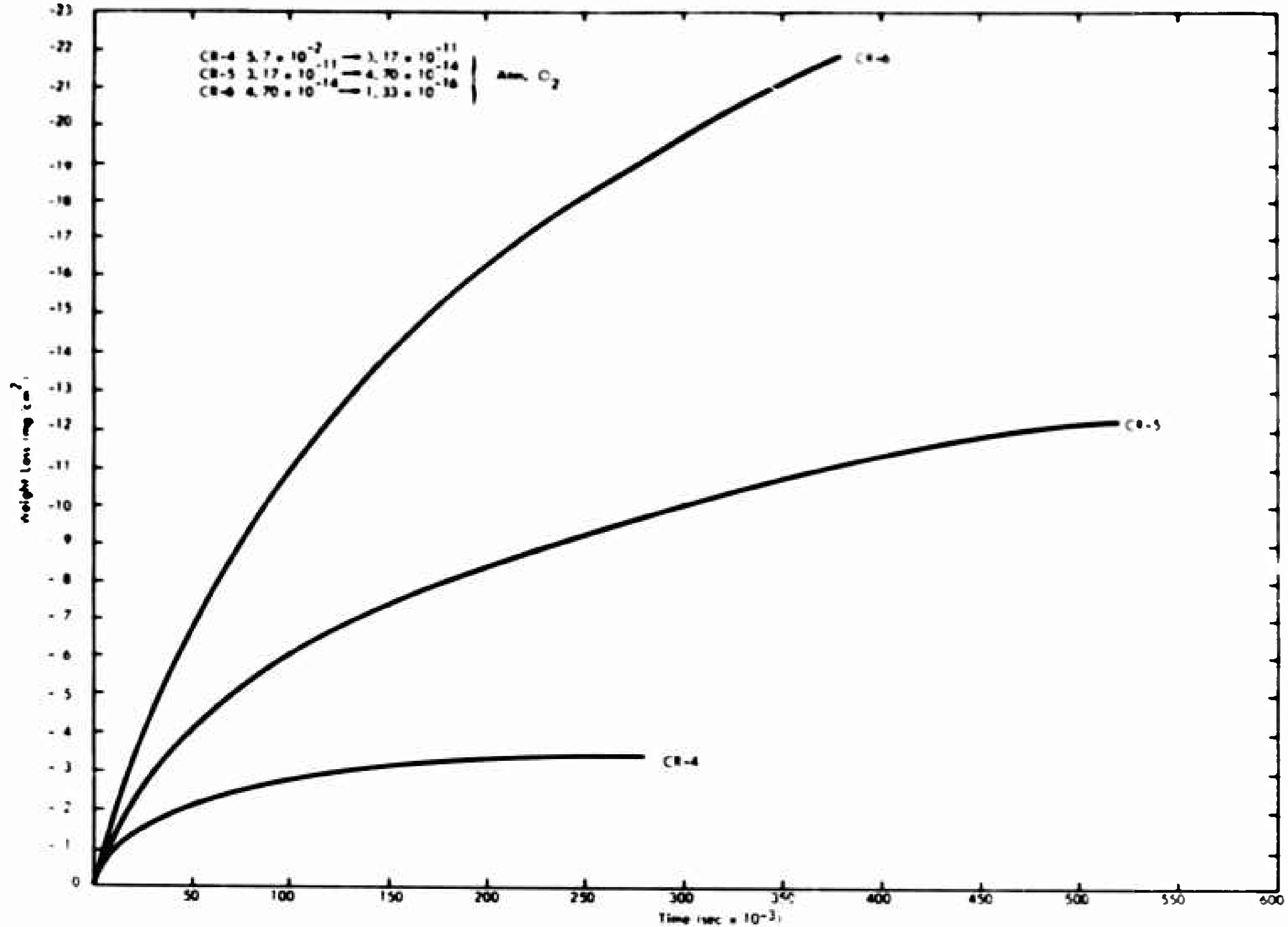


Figure 4. Weight Loss for 1.67:1.00 Molar Ratio Cr_2O_3-Nb_2O_5 as a Function of Time for Various Oxygen Partial Pressure Differentials at 1000°C

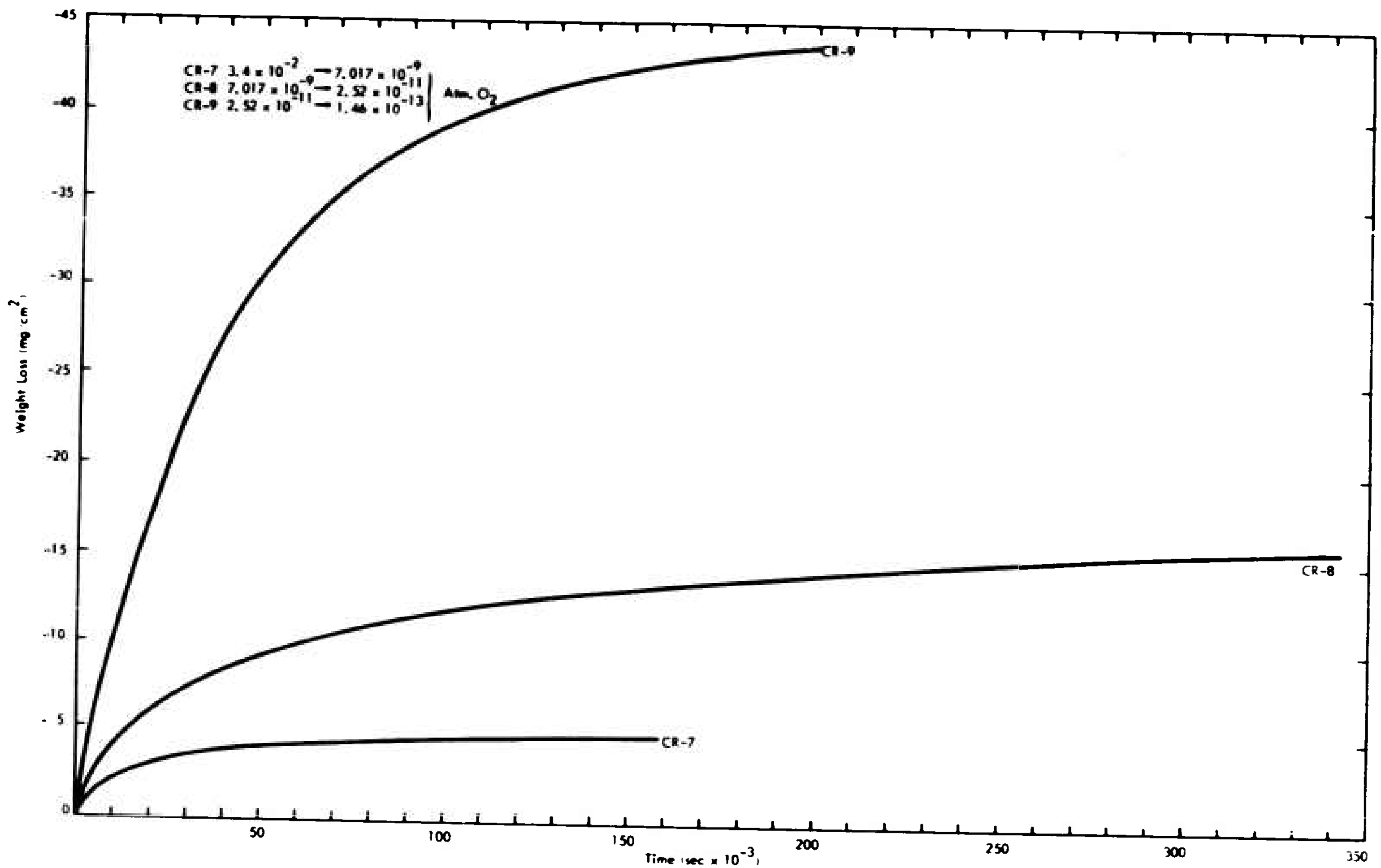


Figure 5. Weight Loss for 1.67:1.00 Molar Ratio Cr_2O_3-Nb_2O_5 as a Function of Time for Various Oxygen Partial Pressure Differentials at 1175°C

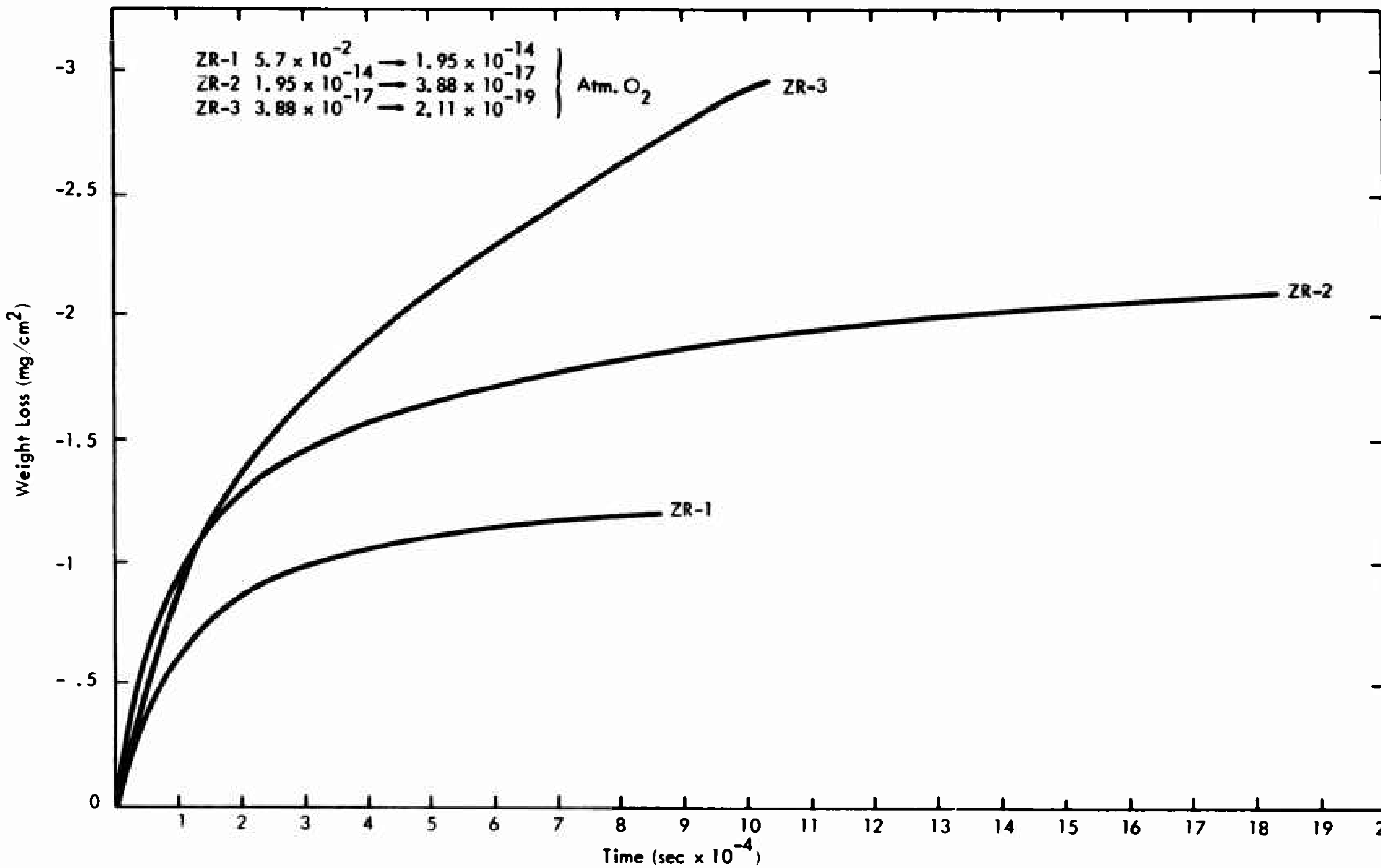


Figure 6. Weight Loss for 2.85:1.00 Molar Ratio ZrO_2-Nb_2O_5 as a Function of Time for Various Oxygen Partial Pressure Differentials at 850°C

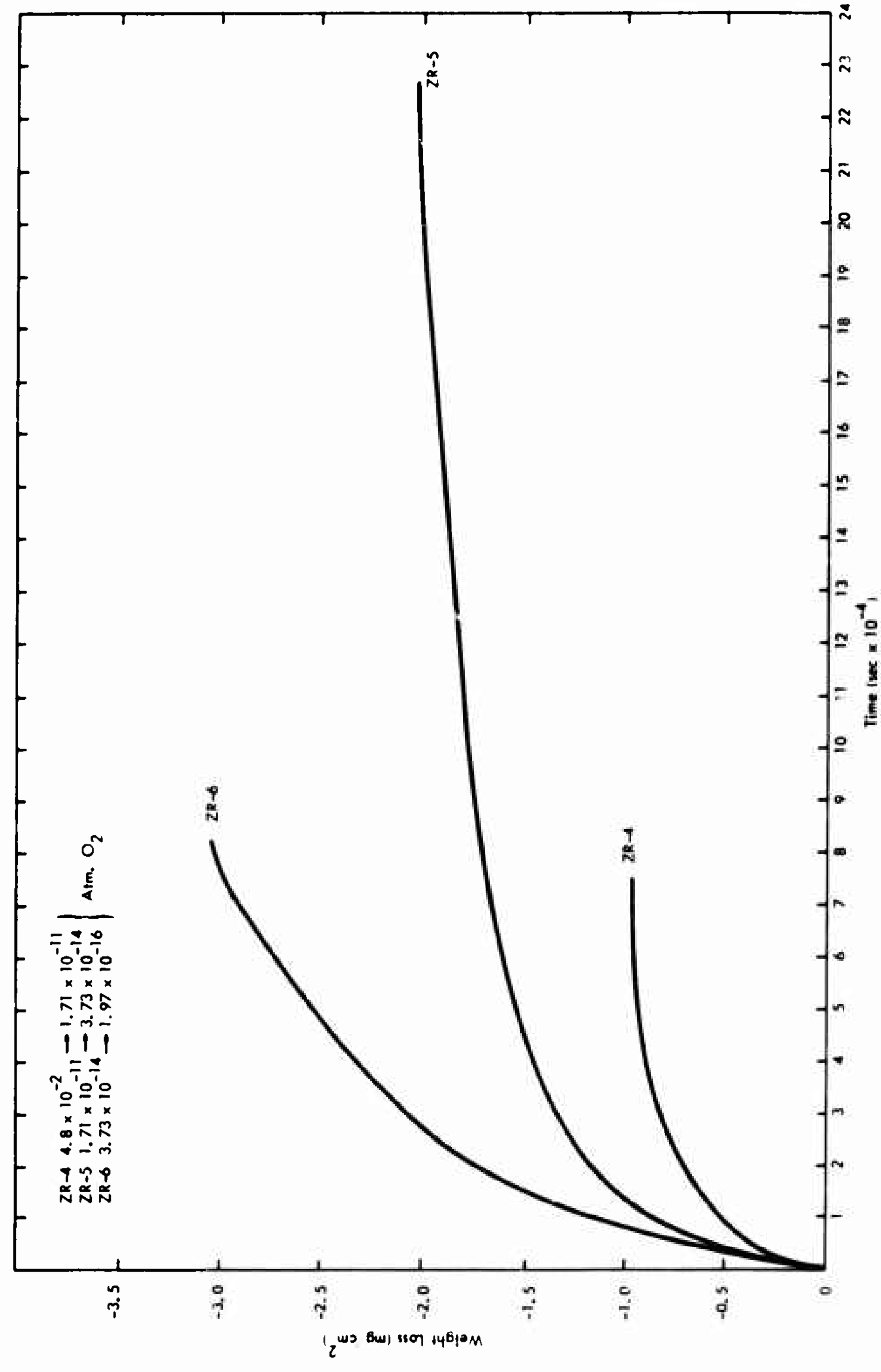


Figure 7. Weight Loss for 2.85:1.00 Molar Ratio ZrO_2-Nb_2O_5 as a Function of Time for Various Oxygen Partial Pressure Differentials at 1000°C

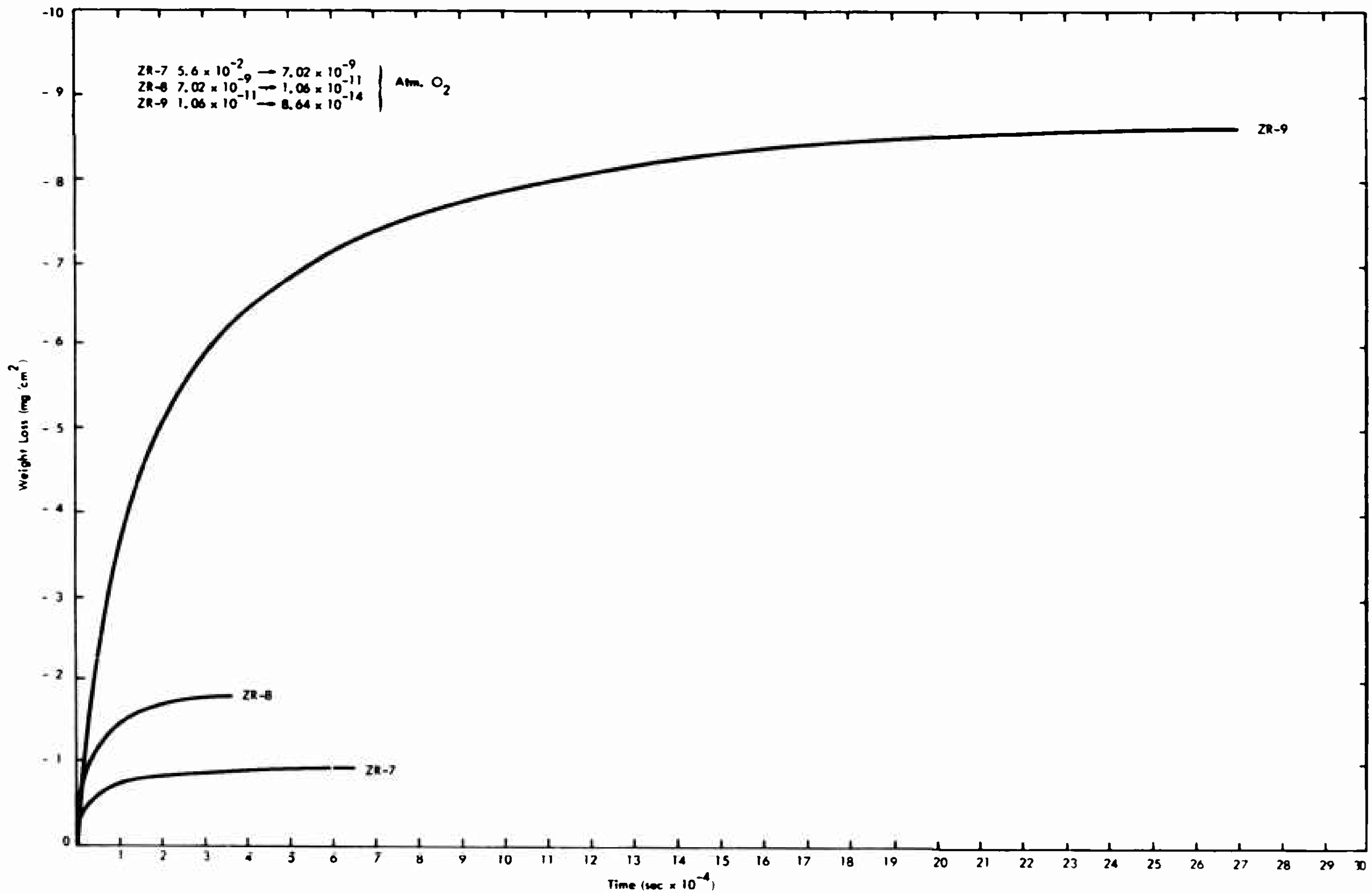


Figure 8. Weight Loss for 2.85:1.00 Molar Ratio ZrO_2-Nb_2O_5 as a Function of Time for Various Oxygen Partial Pressure Differentials at 1175°C

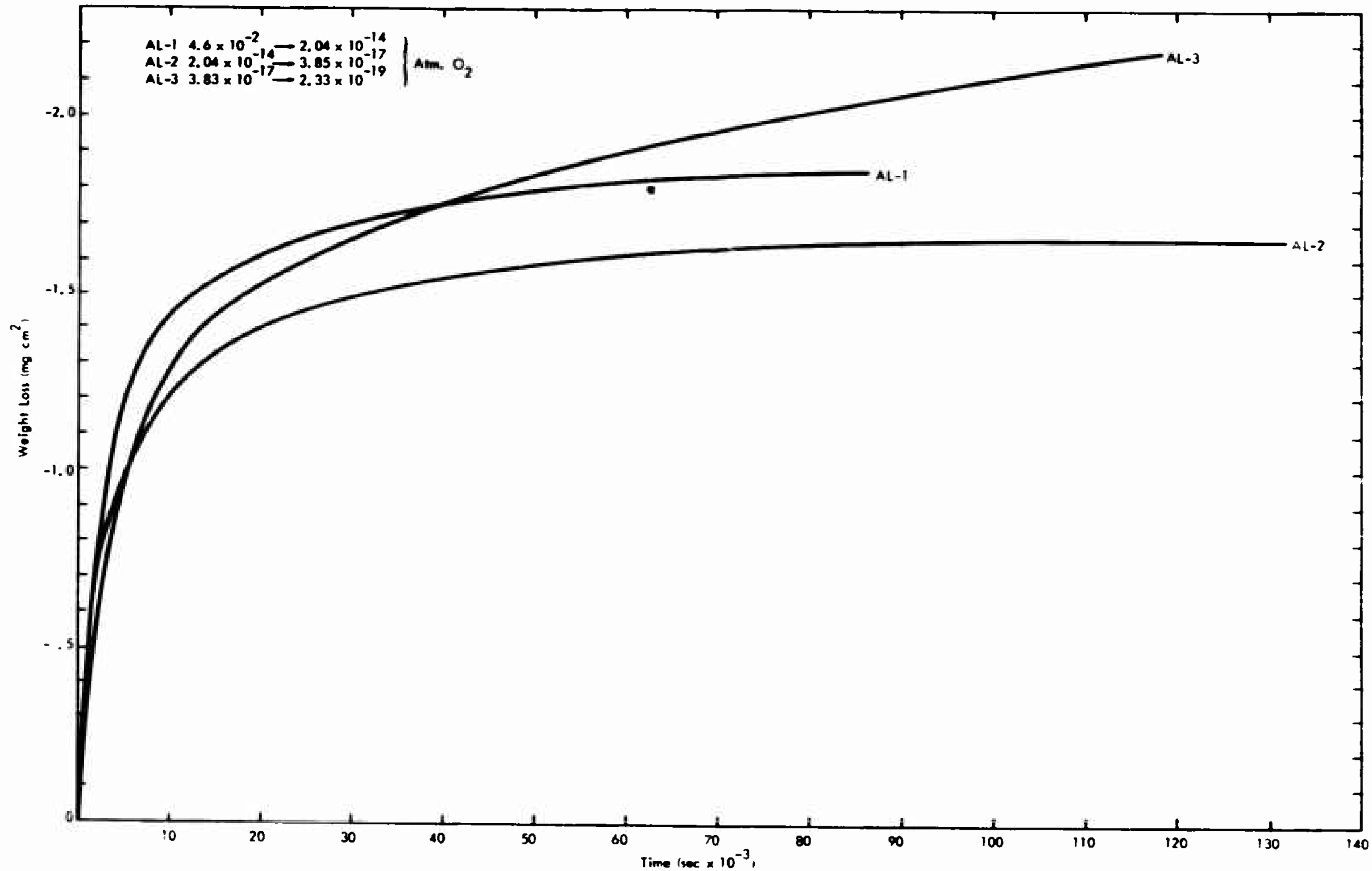


Figure 9. Weight Loss for 2.71:1.00 Molar Ratio Al_2O_3-Nb_2O_5 as a Function of Time for Various Oxygen Partial Pressure Differentials at 850°C

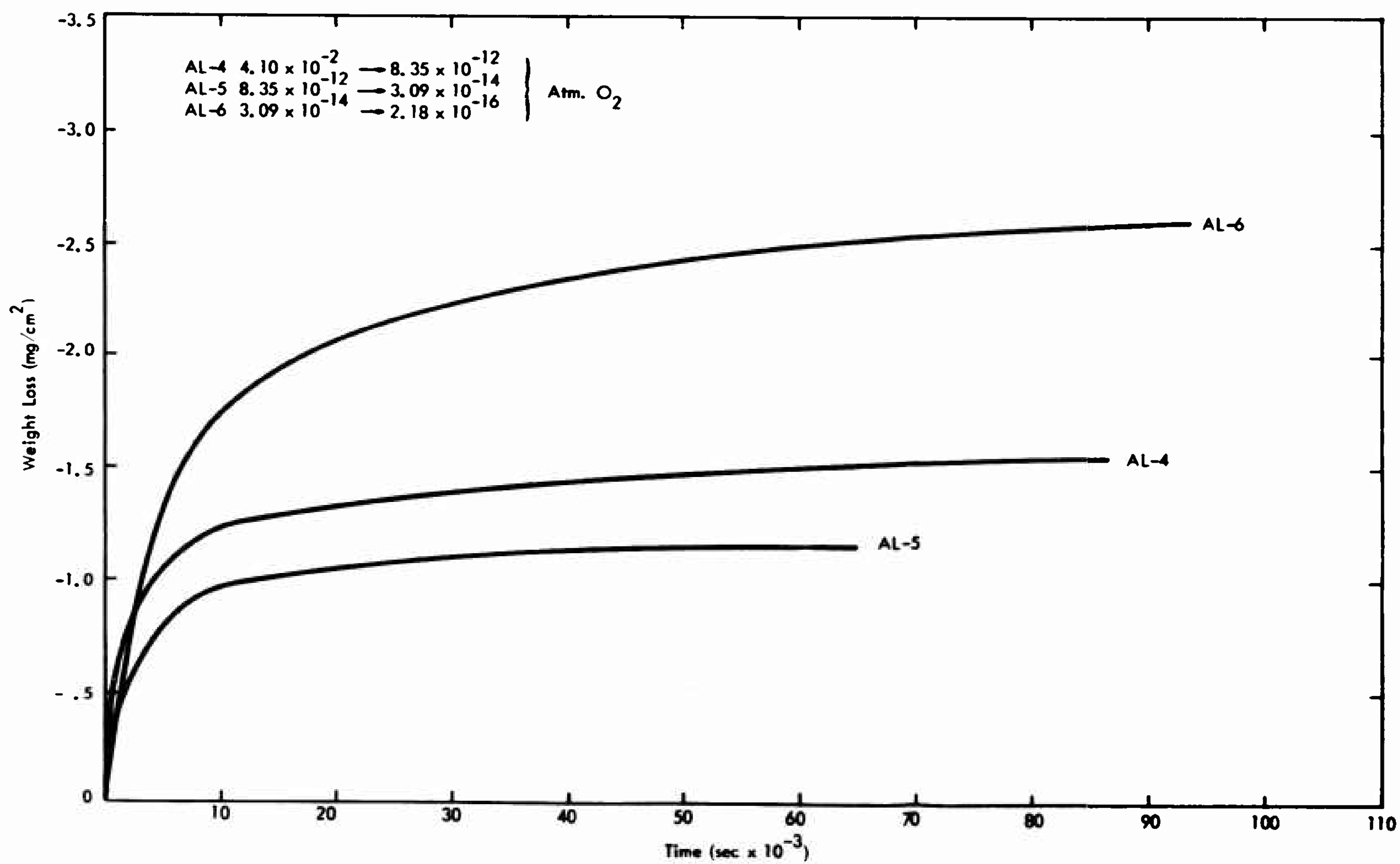


Figure 10. Weight Loss for 2.71:1.00 Molar Ratio Al_2O_3-Nb_2O_5 as a Function of Time for Various Oxygen Partial Pressure Differentials at 1000°C

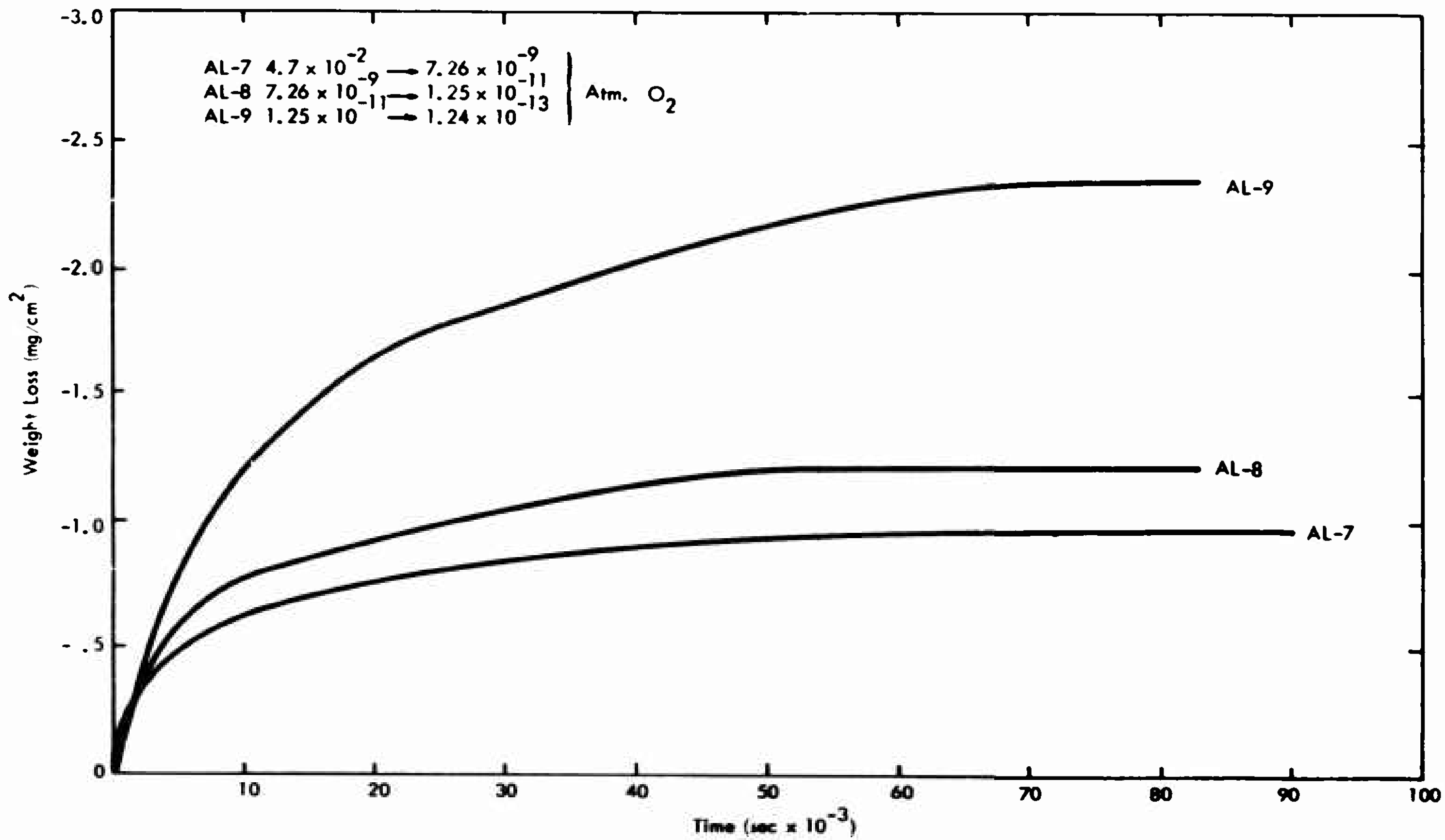


Figure 11. Weight Loss for 2.71:1.00 Molar Ratio Al_2O_3-Nb_2O_5 as a Function of Time for Various Oxygen Partial Pressure Differentials at 1175°C

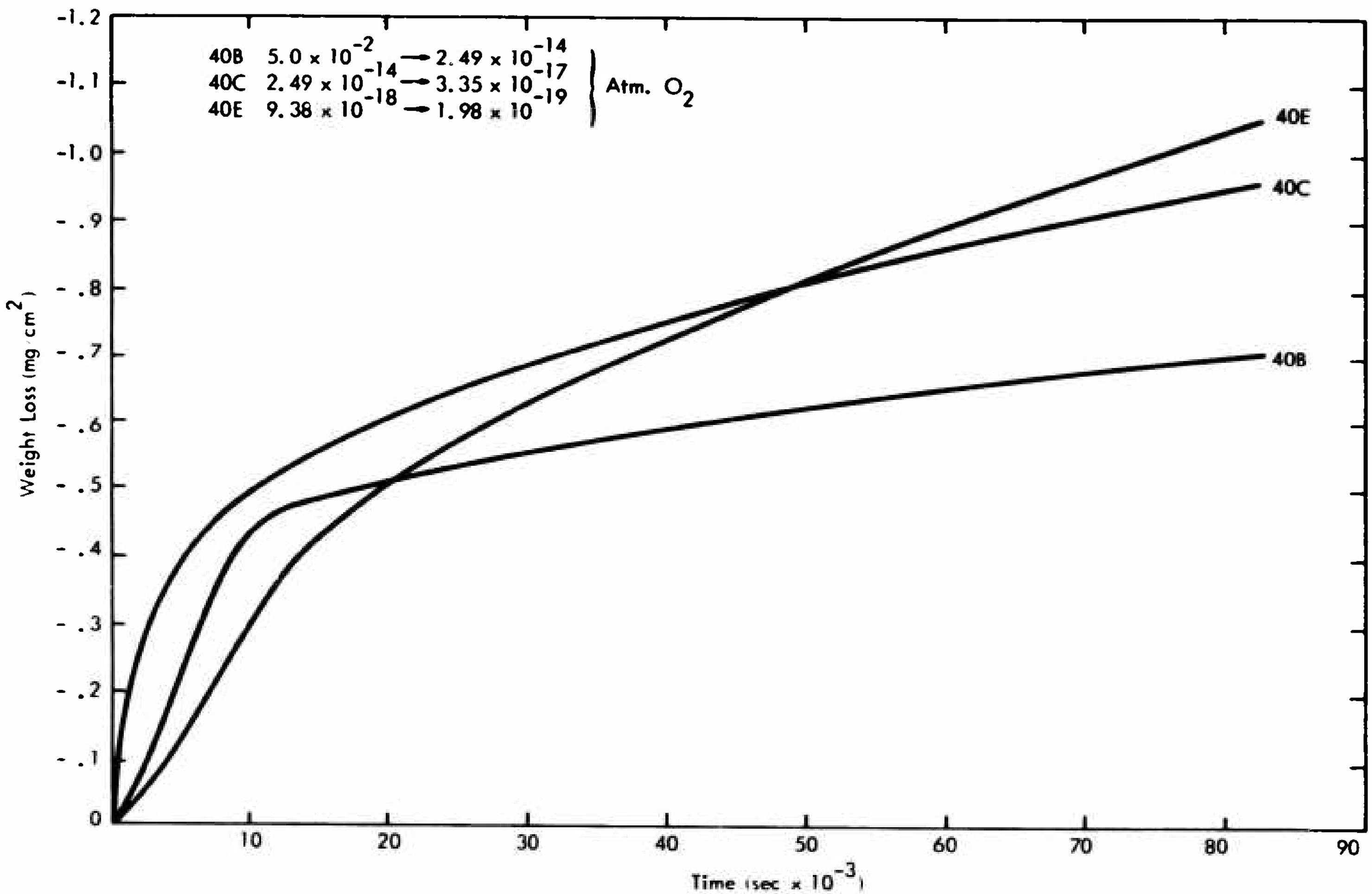


Figure 12. Weight Loss for 1.67:1.00 Molar Ratio TiO_2-Nb_2O_5 as a Function of Time for Various Oxygen Partial Pressure Differentials at 850°C

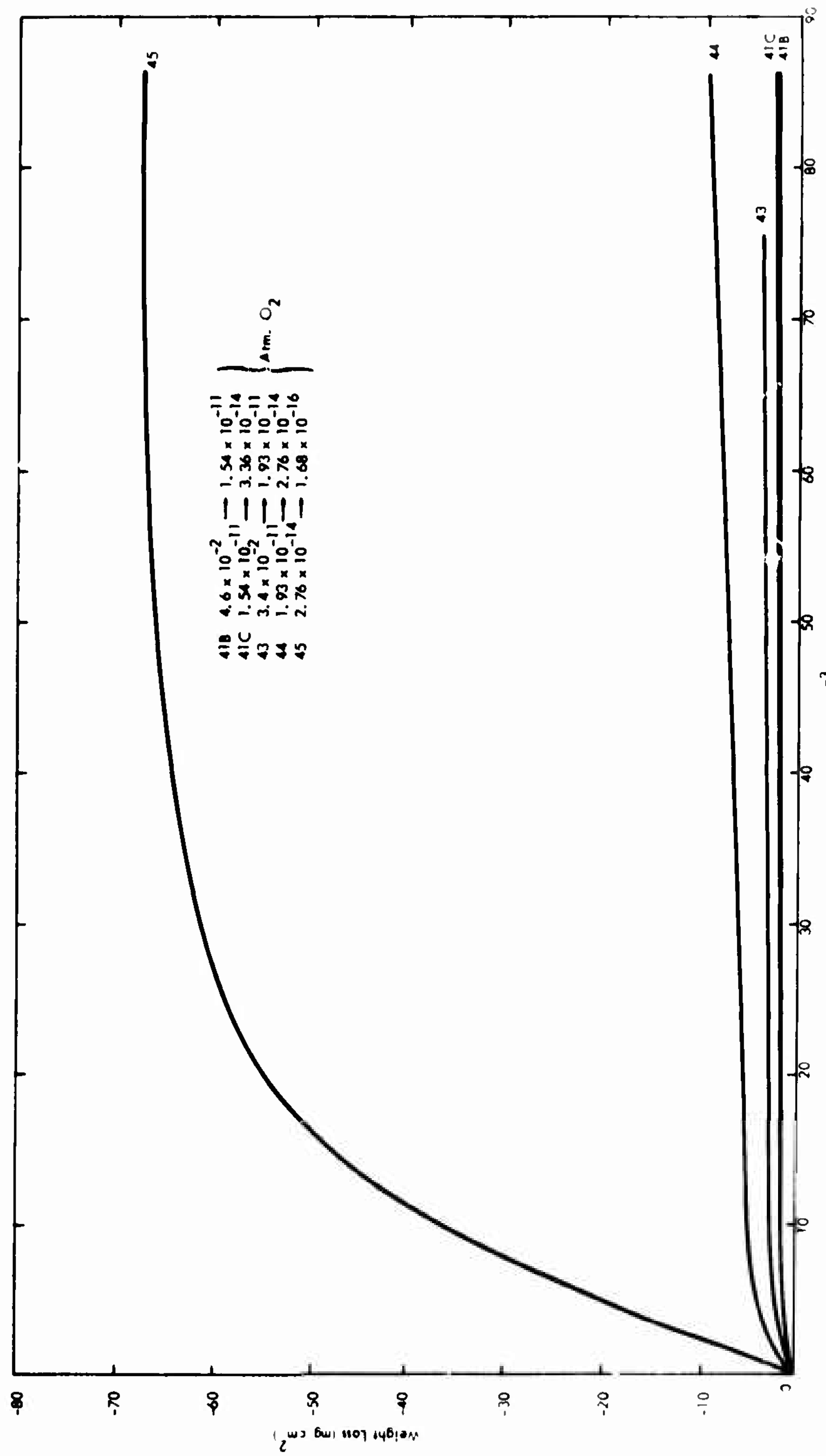


Figure 13. Weight Loss for 1.67:1.00 Molar Ratio TiO_2-Nb_2O_5 as a Function of Time for Various Oxygen Partial Pressure Differentials at 1000°C

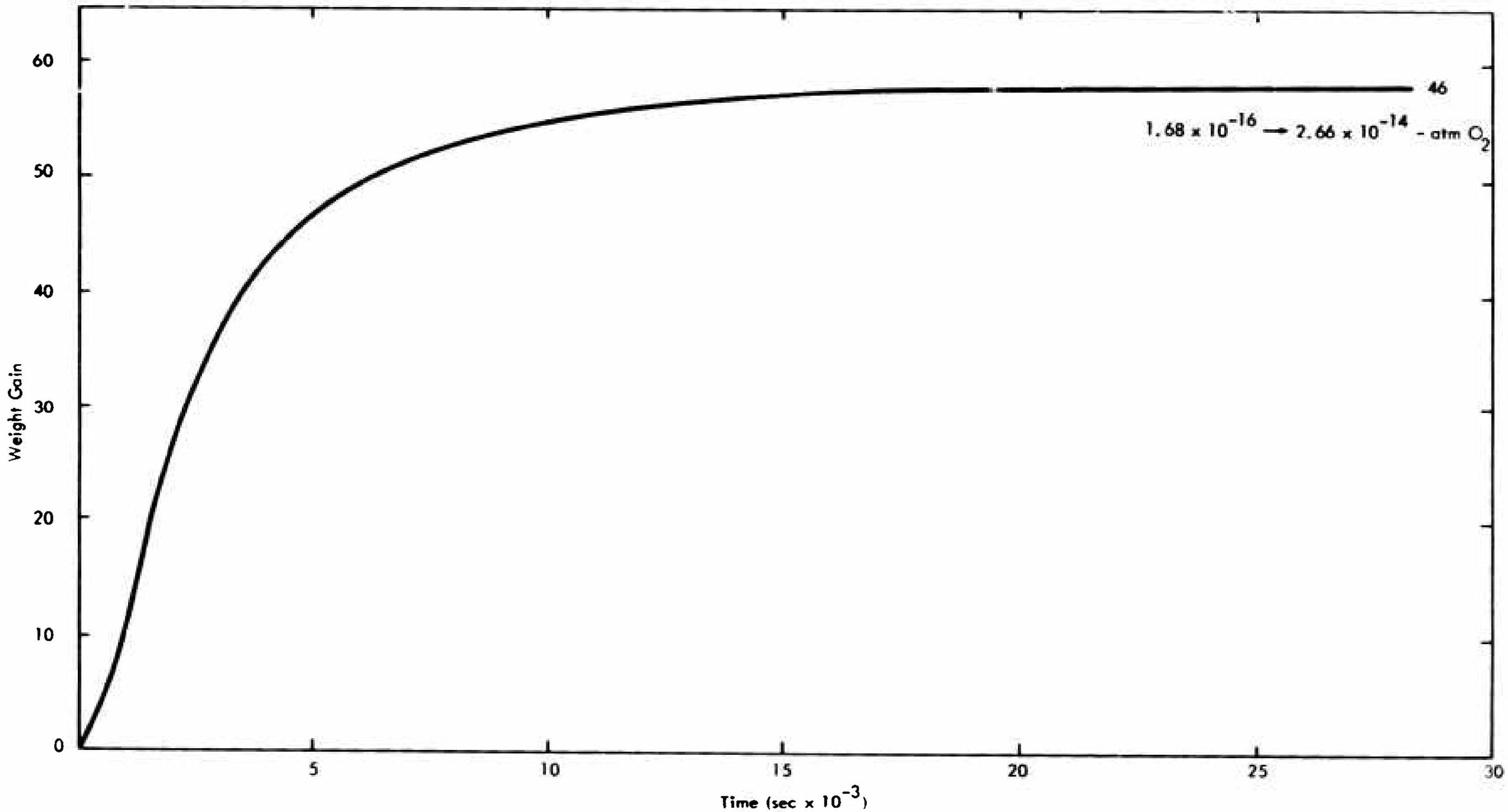


Figure 13 (Continued)

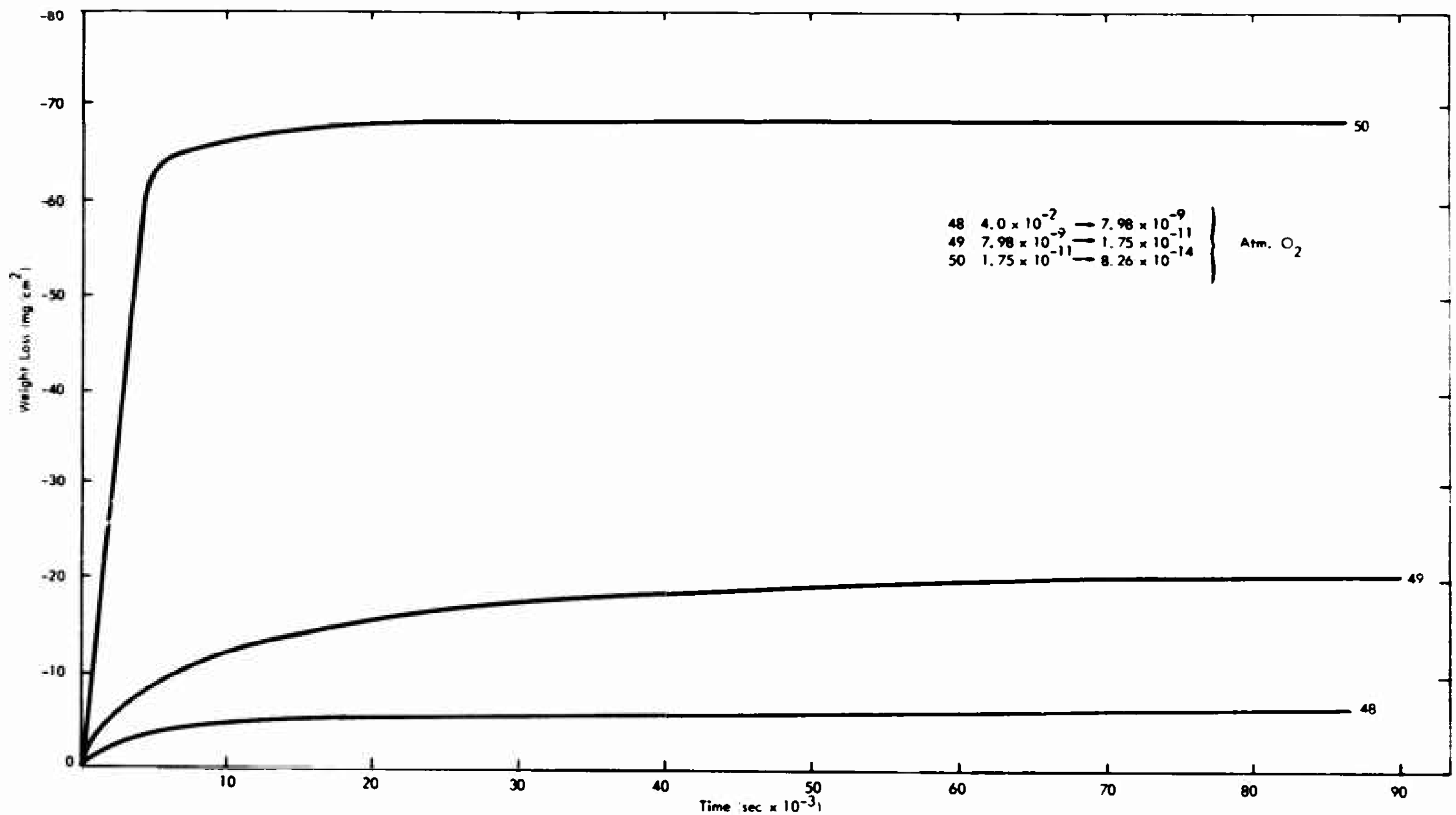


Figure 14. Weight Loss for 1.67:1.00 Molar Ratio TiO_2-Nb_2O_5 as a Function of Time for Various Oxygen Partial Pressure Differentials at 1175°C

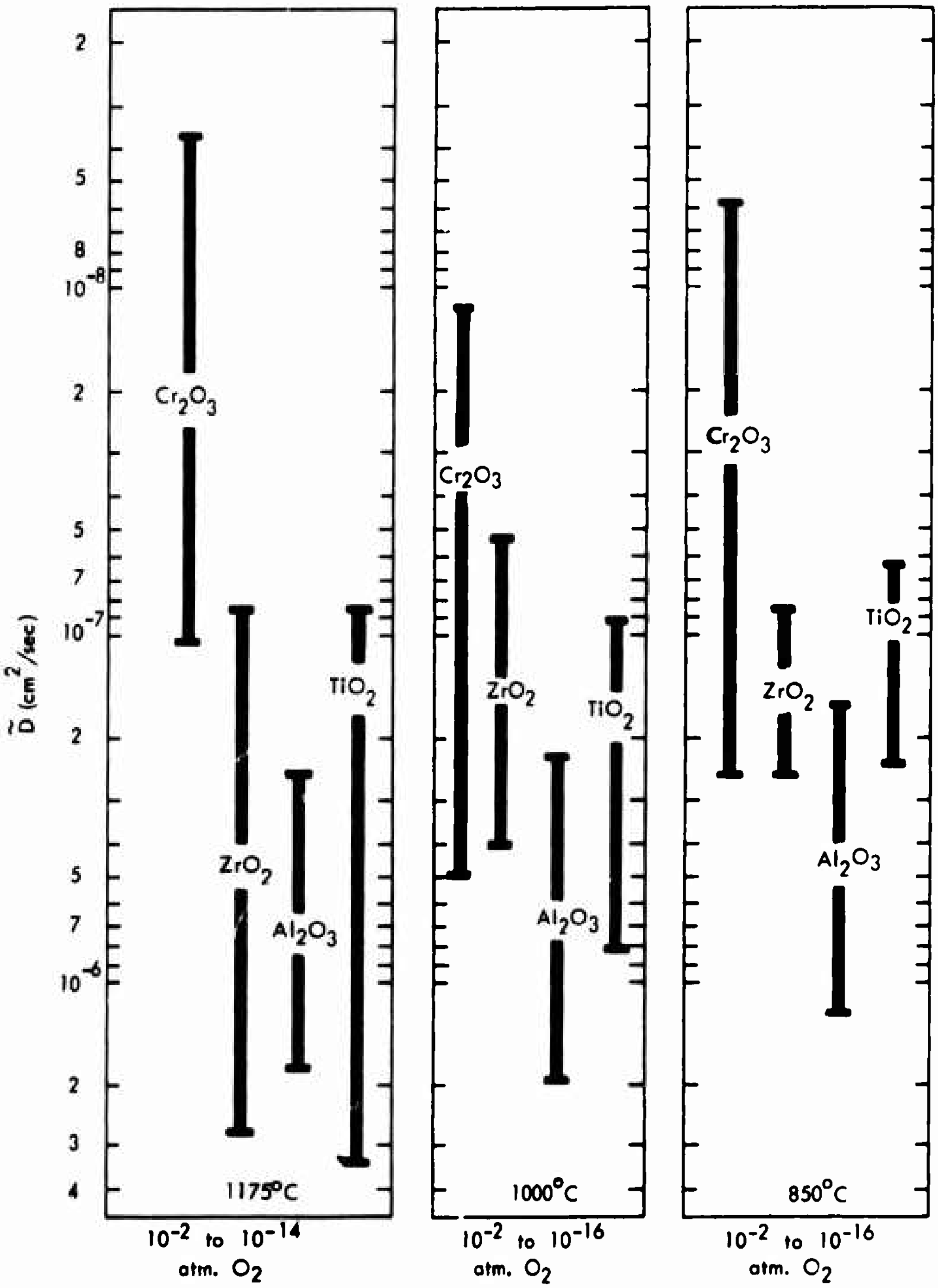


Figure 15. Summary of the Oxygen Diffusion Data Determined for Four Binary Niobates Tested

nonstoichiometry did this occur. Figure 15 clearly indicates the chemical diffusion coefficient for oxygen is lowest in the Nb_2O_5-Cr_2O_3 system. As will be described later, this is further substantiated by additional oxidation work on chromium containing alloys and intermetallics. Figures 16-19 compare the values of the diffusion coefficients plotted as a function of temperature and determined by plotting log (l-M(t)/Q) vs time for the four systems evaluated. Figures 20-23 compare the values of the diffusion coefficients plotted as a function of temperature determined by plotting $(M(t)/A)^2$ vs time. The numbers ①, ②, and ③ correspond to the degree of departure from stoichiometry as listed in Table I. One ① corresponds to a nominal 1/20 CO/CO_2 ration, two ② corresponds to a nominal 1/1 CO/CO_2 ratio, and three ③ corresponds to a nominal 20/1 CO/CO_2 ratio at the temperatures indicated. Where no numbers are shown on the graph, the data was randomly scattered within the bands indicated.

Figures 16-27 show the results for the individual oxides Cr_2O_3-Nb_2O_5, ZrO_2-Nb_2O_5, Al_2O_3-Nb_2O_5, and TiO_2-Nb_2O_5. The diffusion data determined by using the logarithmic model are valid for values of $Dt/l^2 \geq 0.15$. These results should not contain the uncertainty in the selection of a zero time for the reaction, and equilibrium with the flowing gas stream should be established. The parabolic model gives the diffusion coefficients for $Dt/l^2 \leq 0.25$ or during the initial stages of the reaction.

Figures 24-27 show the deviation from stoichiometry as a function of oxygen partial pressure and were determined utilizing the molecular weights of the samples according to the formula shown in the first column of Table 1.

2.5.1 Cr_2O_3-Nb_2O_5

The chemical diffusion coefficients determined from the logarithmic model (Figure 16) showed no correlation between the degree of nonstoichiometry or the temperature. However, the parabolic model (Figure 20) showed a definite trend toward slower oxygen transport rates at larger deviations from stoichiometry. In addition, the diffusion coefficients at 1175°C were smaller

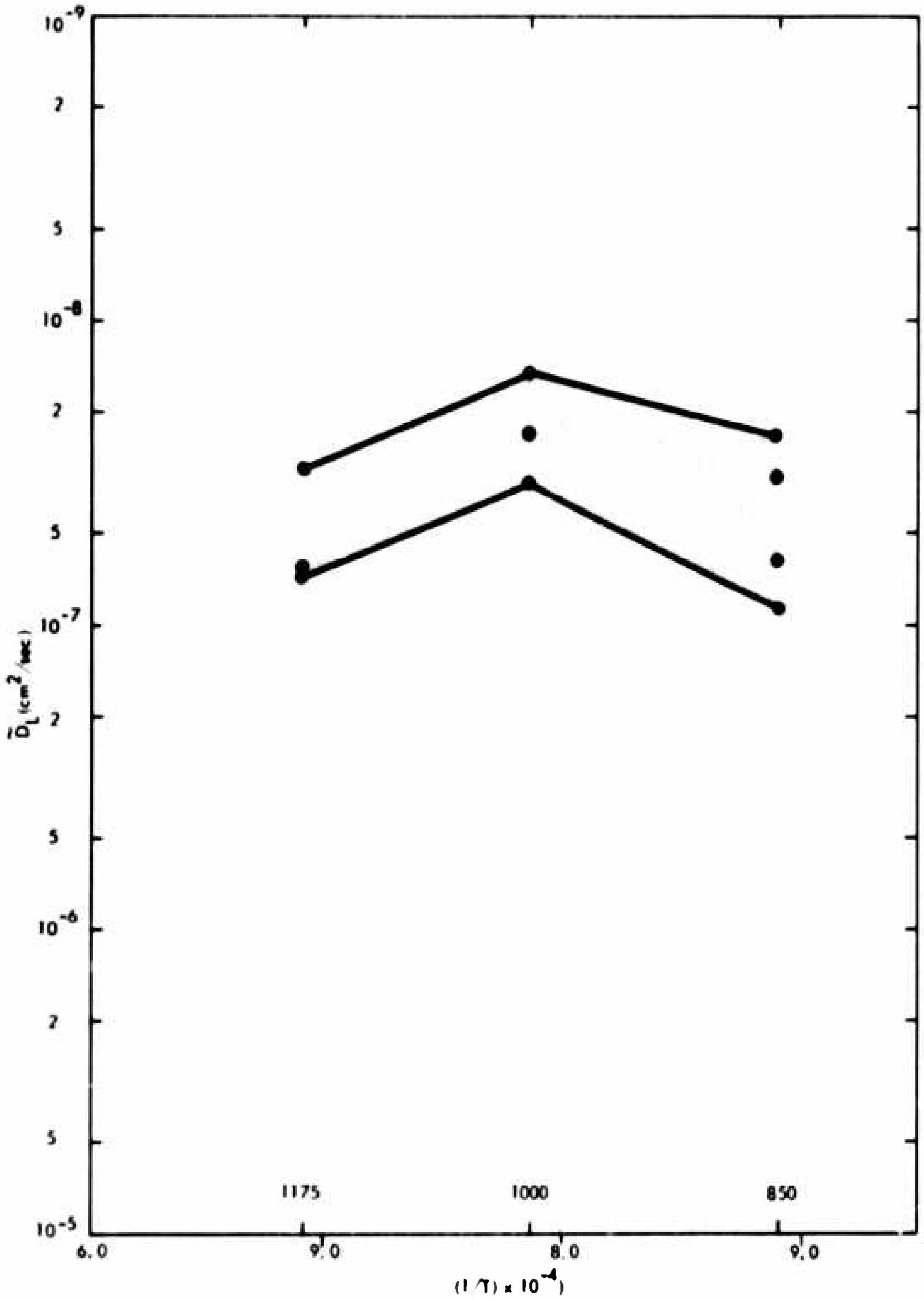


Figure 16. Chemical Diffusion Coefficients for the System Nb_2O_5-Cr_2O_3 as Determined by the Logarithmic Model

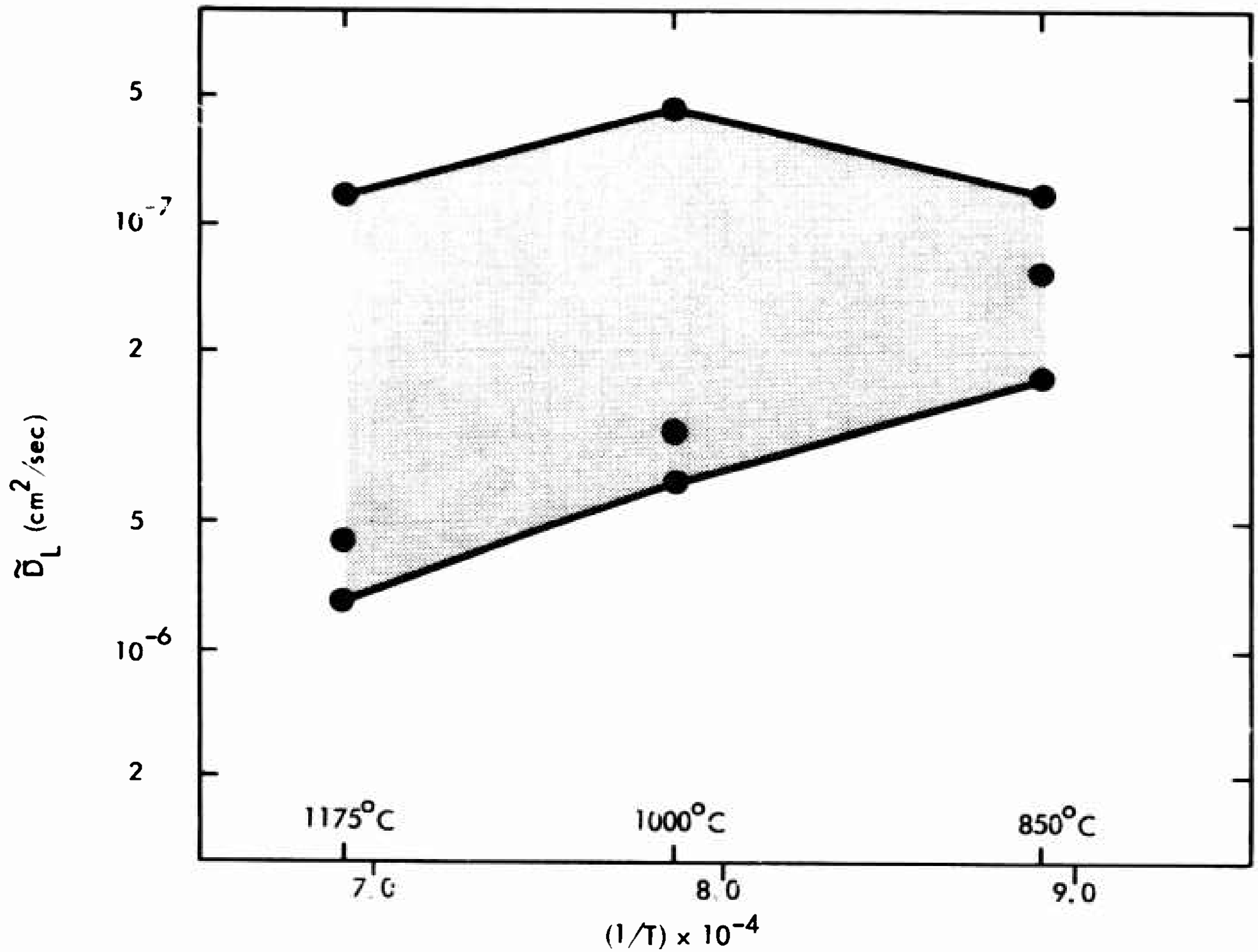


Figure 17. Chemical Diffusion Coefficients for the System Nb_2O_5- ZrO_2 as Determined by the Logarithmic Model

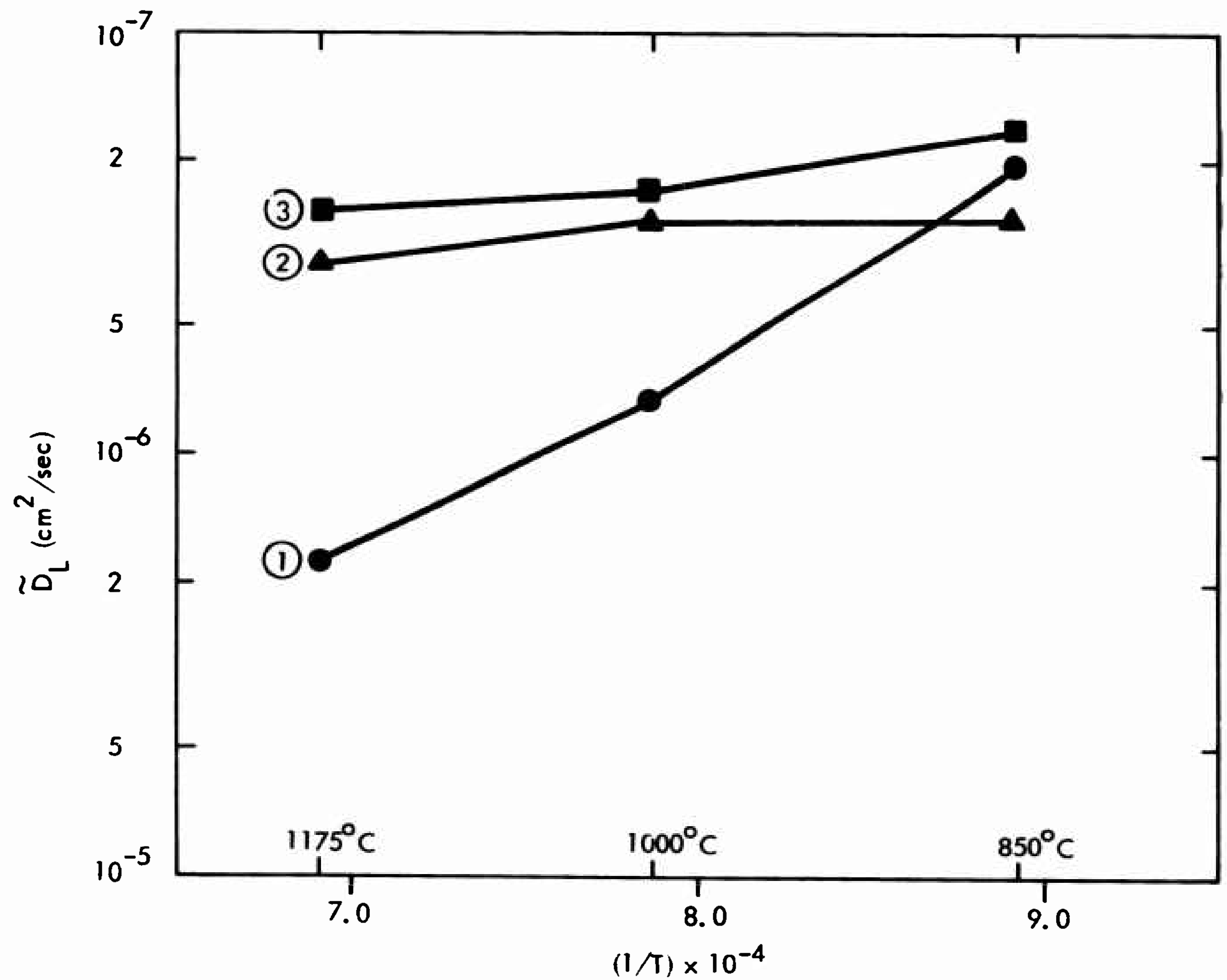


Figure 18. Chemical Diffusion Coefficients for the System Nb_2O_5-Al_2O_3 as Determined by the Logarithmic Model

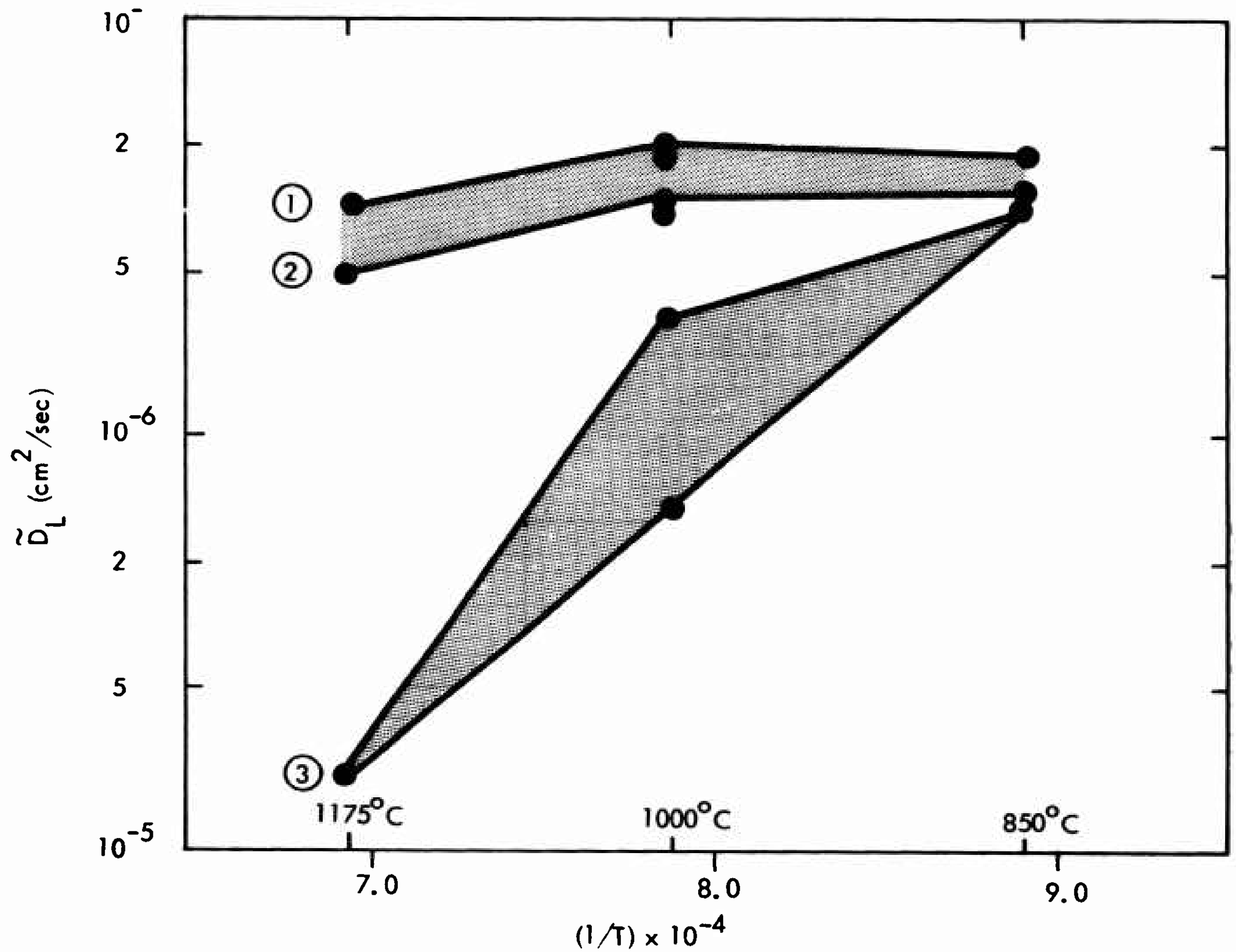


Figure 19. Chemical Diffusion Coefficients for the System Nb_2O_5- TiO_2 as Determined by the Logarithmic Model

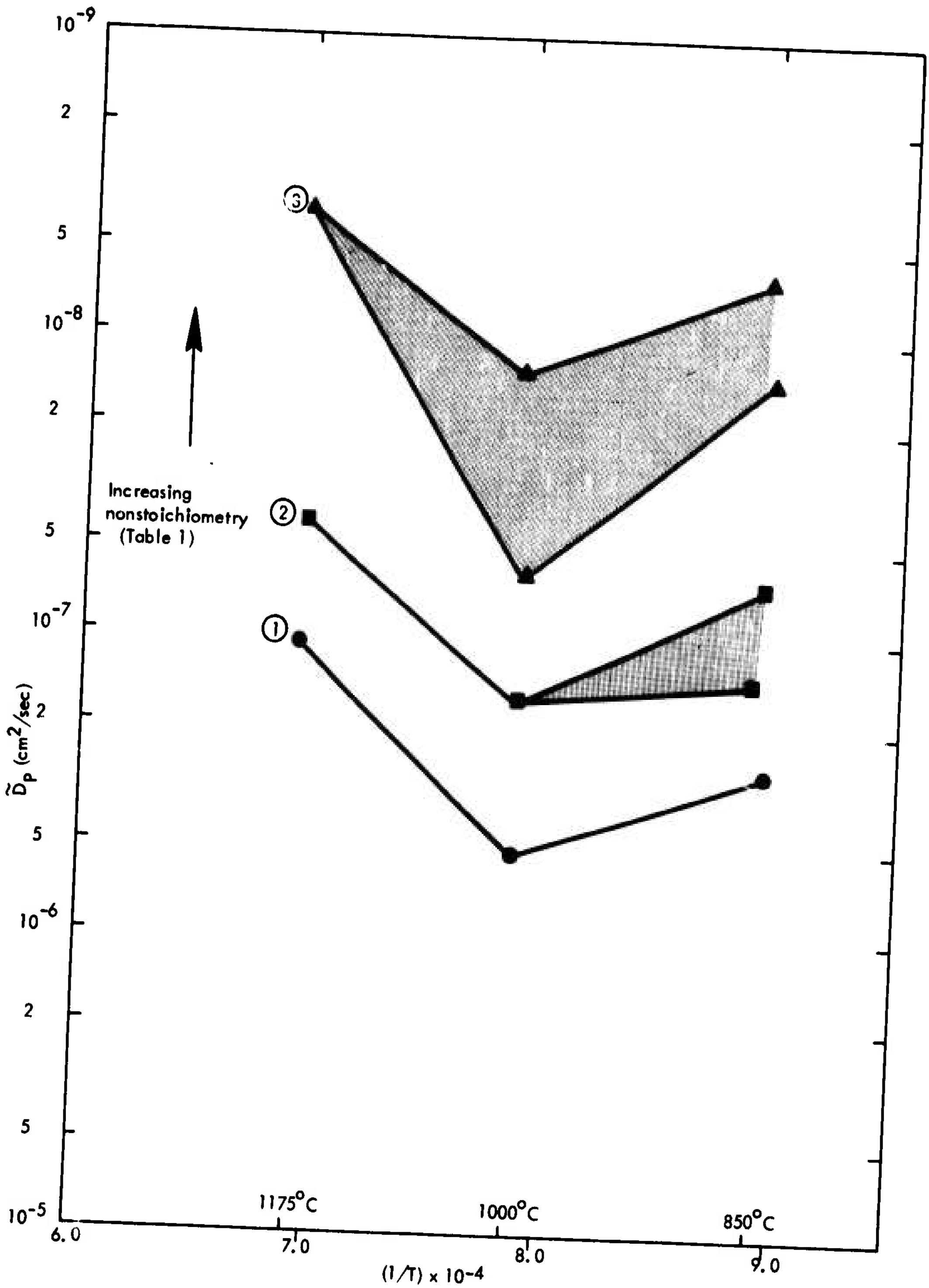


Figure 20. Chemical Diffusion Coefficients for the System Nb_2O_5-Cr_2O_3 as Determined by the Parabolic Model

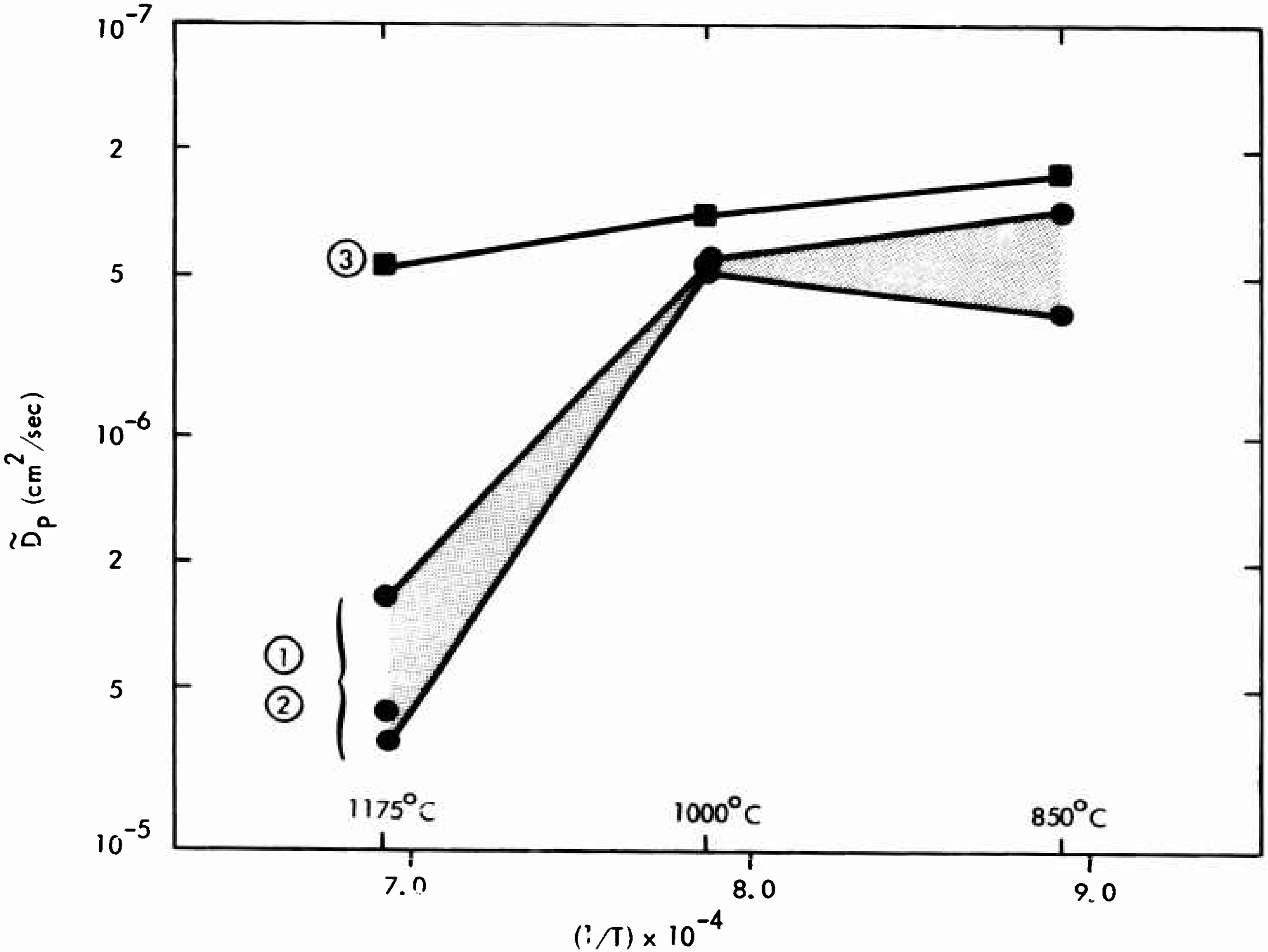


Figure 21. Chemical Diffusion Coefficients for the System Nb_2O_5-ZrO_2 as Determined by the Parabolic Model

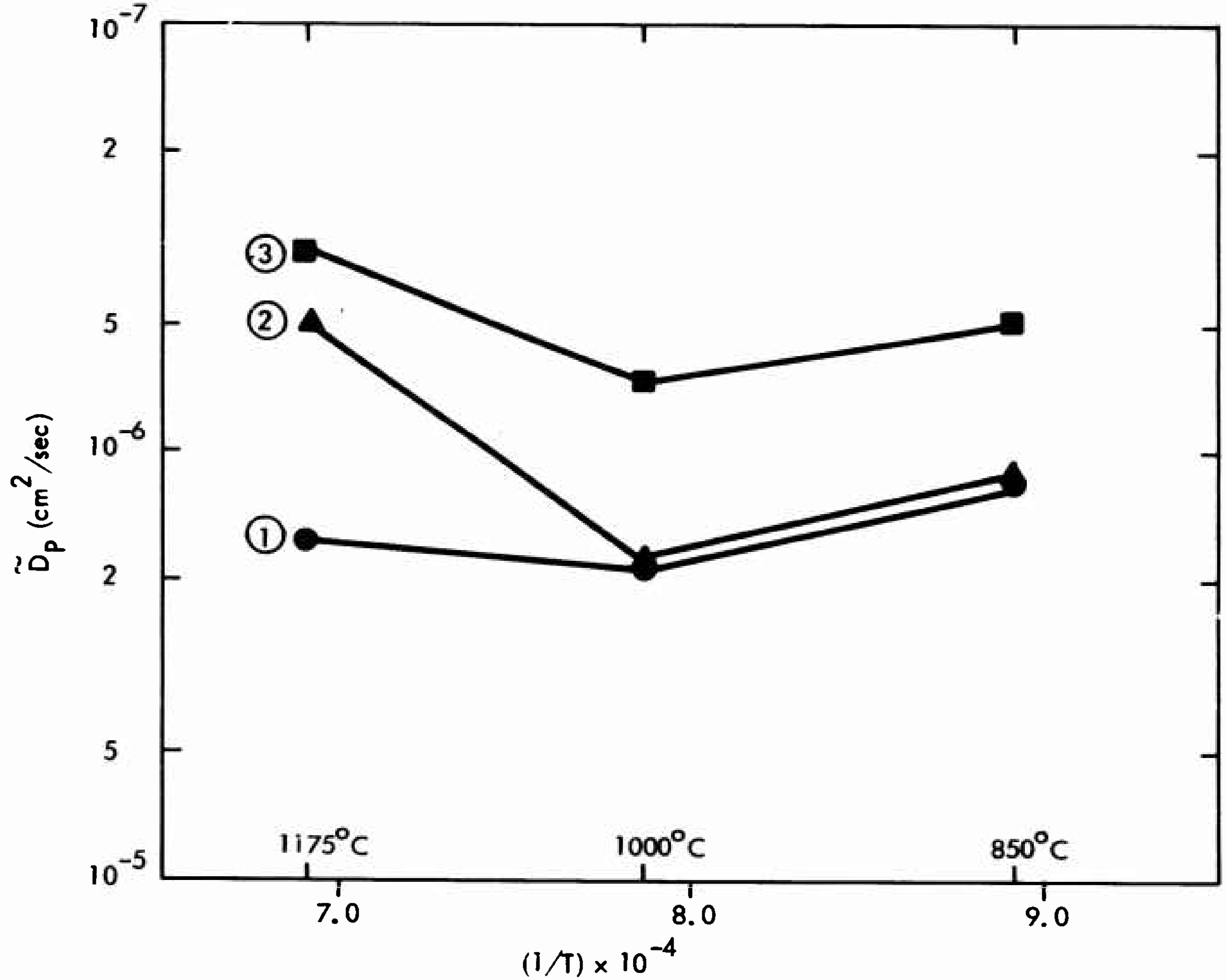


Figure 22. Chemical Diffusion Coefficients for the System Nb_2O_5-Al_2O_3 as Determined by the Parabolic Model

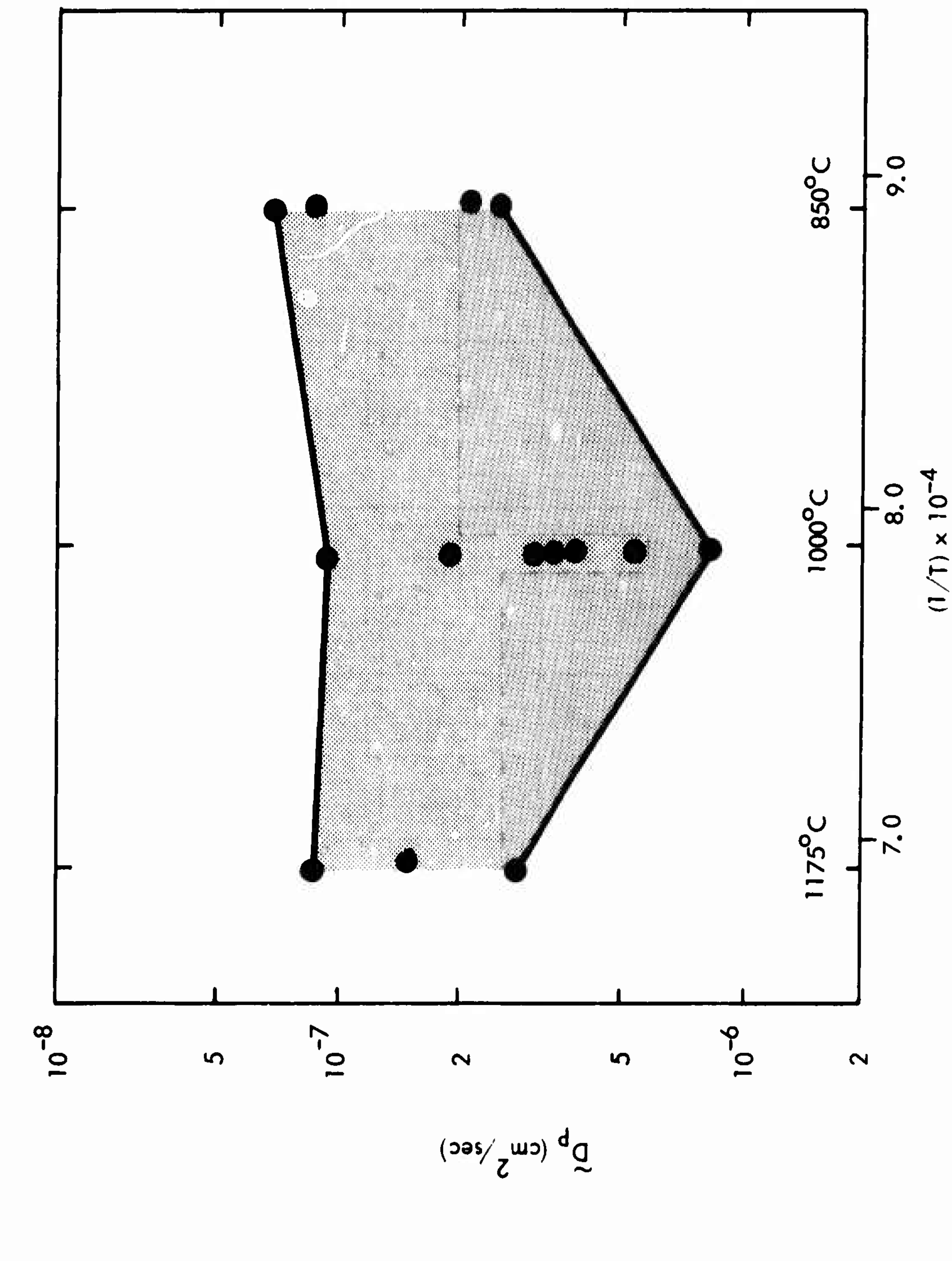


Figure 23. Chemical Diffusion Coefficients for the System Nb_2O_5-TiO_2 as Determined by the Parabolic Model

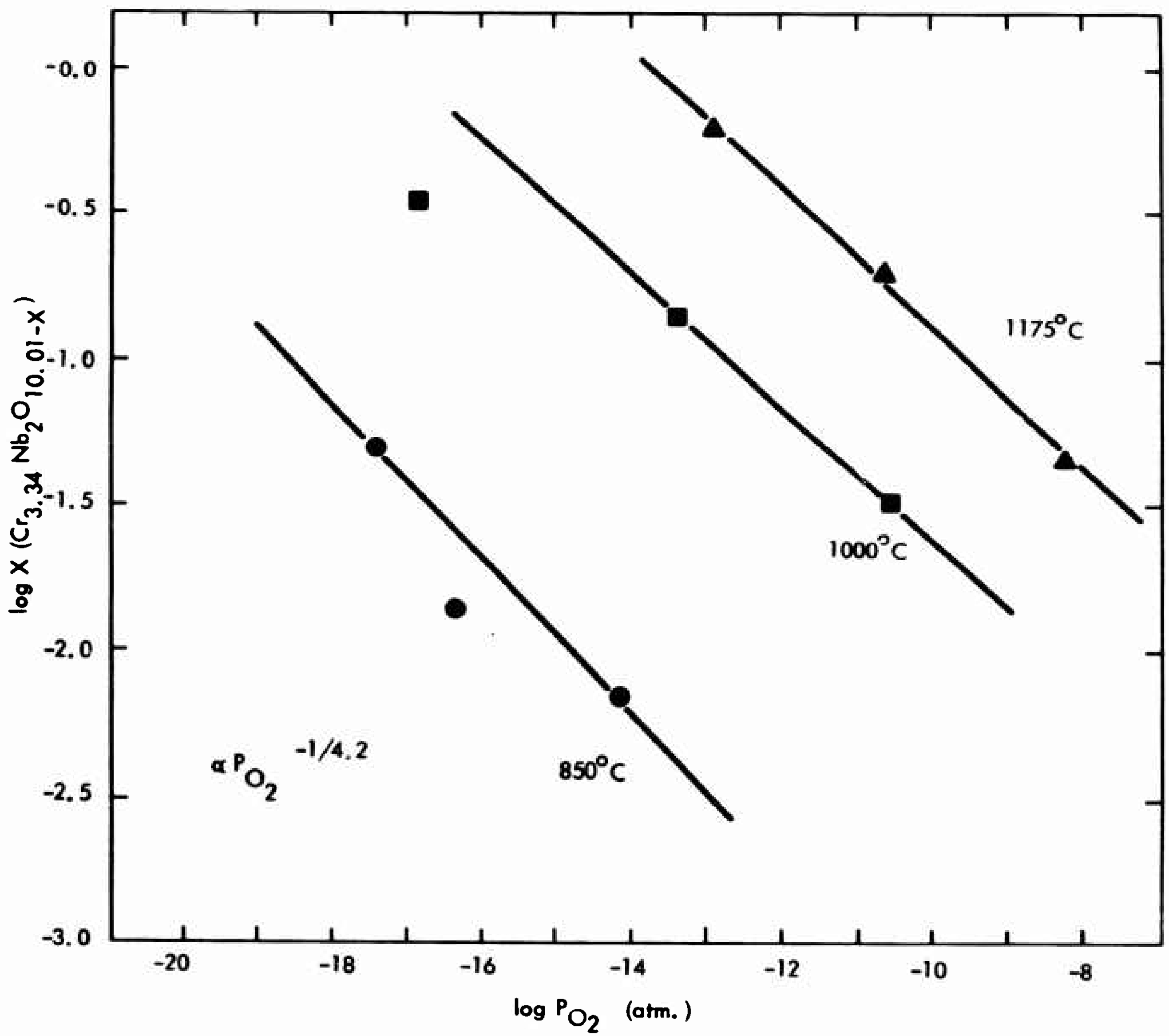


Figure 24. Nonstoichiometry for 1.67:1.00 Molar Ratio Cr_2O_3-Nb_2O_5 as a Function of Oxygen Partial Pressure

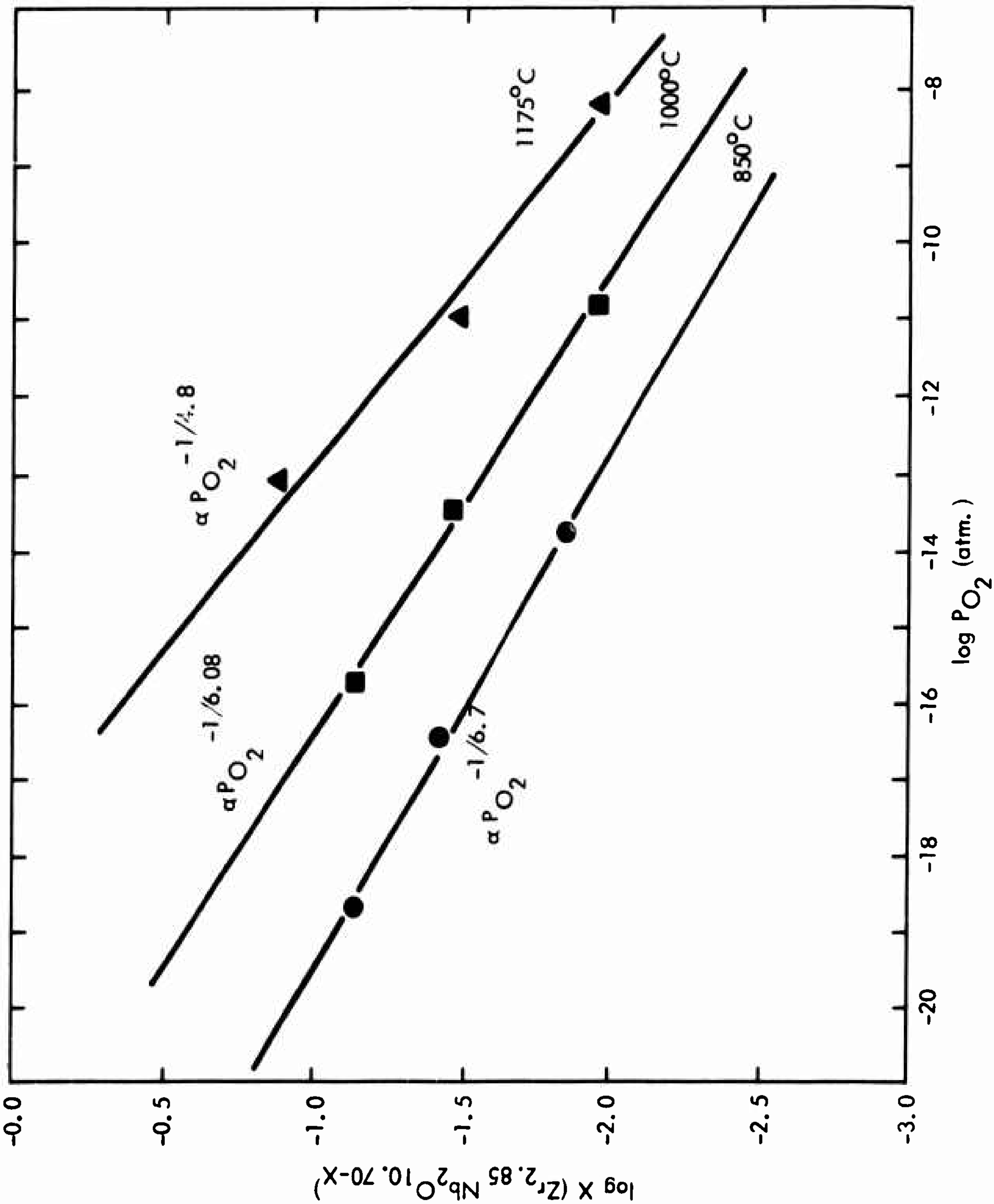


Figure 25. Nonstoichiometry for 2.85:1.00 Molar Ratio ZrO_2-Nb_2O_5 as a Function of Oxygen Partial Pressure

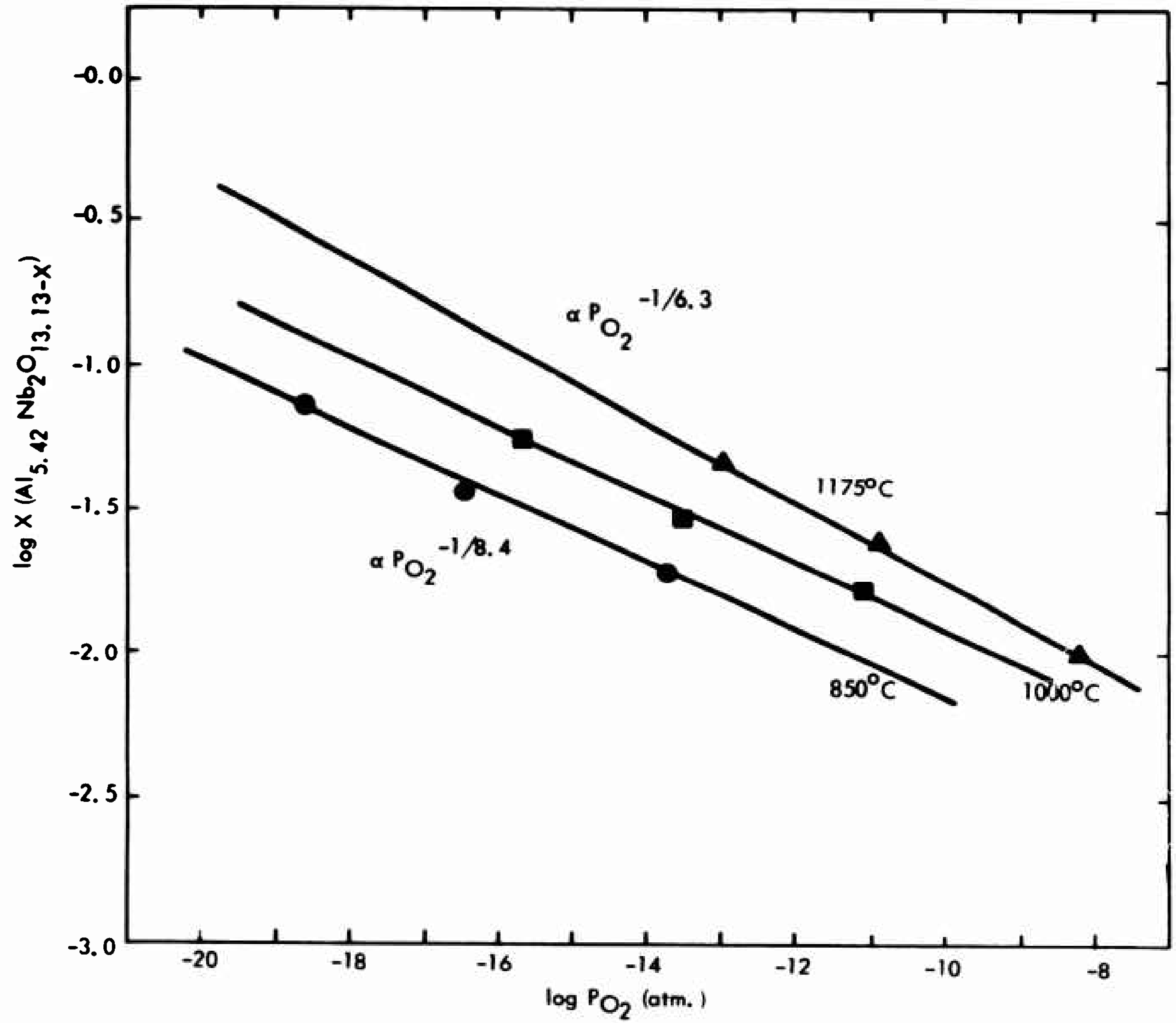


Figure 26. Nonstoichiometry for 2.71:1.00 Molar Ratio Al_2O_3-Nb_2O_5 as a Function of Oxygen Partial Pressure

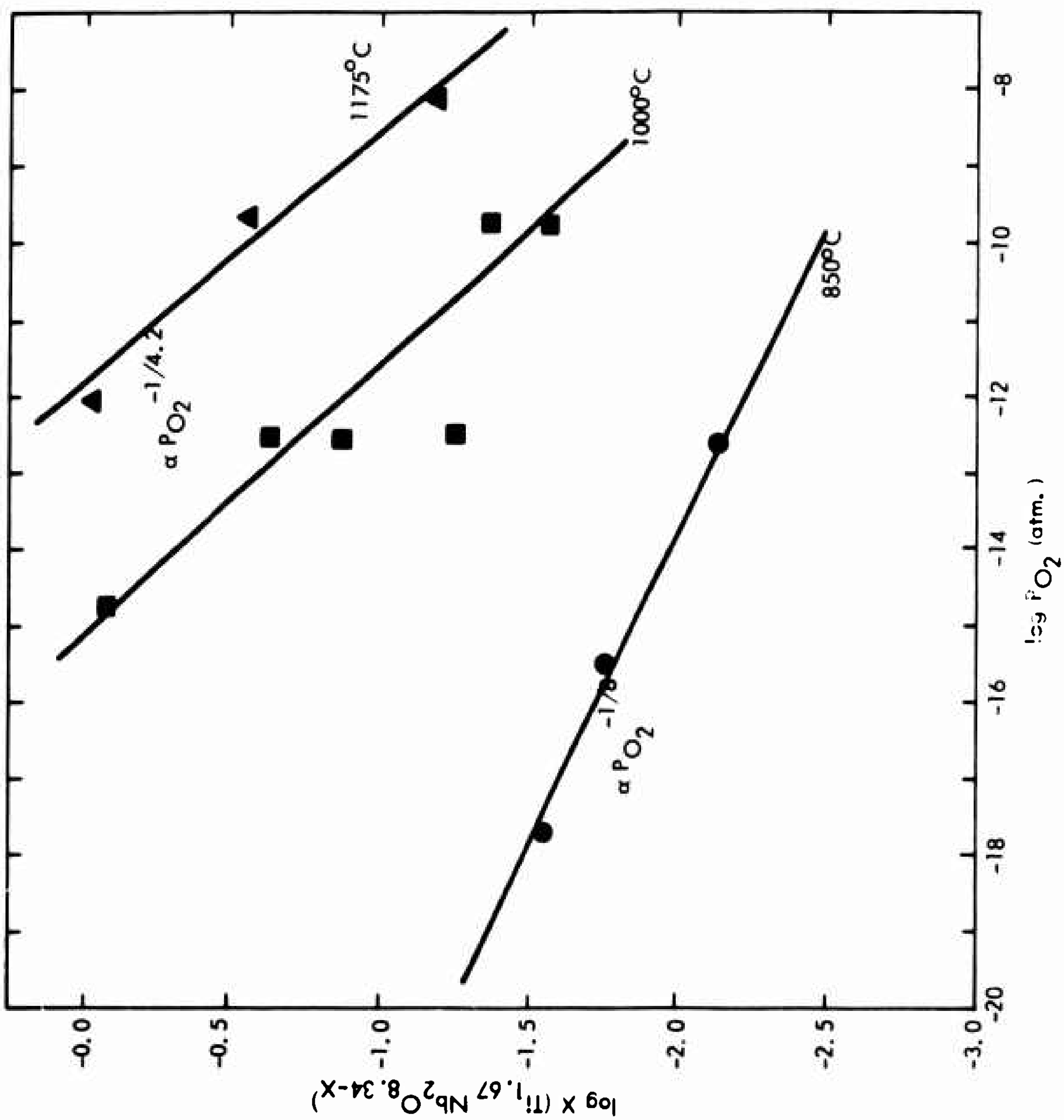


Figure 27. Nonstoichiometry for 1.67:1.00 Molar Ratio TiO_2-Nb_2O_5 as a Function of Oxygen Partial Pressure

than those at 850°C. From Figure 24, the weight loss of oxygen from the sample is proportional to the -1/4.17 power of oxygen partial pressure, which indicates after Kofstad[3], a singly charged oxygen vacancy as the anion defect in the Cr_2O_3-Nb_2O_5 lattice. In this system, Goldsmith[29] reports a single rutile phase from 800°C to the melting point for the oxide in equilibrium with air. However, there is no information available which details the phase equilibrium for the Nb_2O_5-Cr_2O_3 system. The diffusion results could indicate that different phases, which are in equilibrium at the various partial pressures of oxygen, could control the rate of oxygen transport.

Several workers[16-18] have reported the possibility of the existence of a series of intermediate phases in many oxides which show large deviations from stoichiometry. In this case, the point defects, such as singly or doubly charged anion vacancies, previously determined by measuring the pressure dependence of nonstoichiometry cannot be considered. The rate of diffusion is now controlled by the diffusion through a suboxide phase which is in equilbrium with an oxygen partial pressure. Looking at Figures 3, 4, and 5, it is apparent that equilibrium was not reached for CR-2, CR-3, CR-6, and CR-9. Some of these systems were equilibrated for times up to 6 days (CR-5), and equilibrium was not achieved.

By estimating or measuring the total deviation from stoichiometry in a geometric configuration such as a powder, which would not require an extended time period to achieve equilibration, an equilibrium weight loss for oxygen pressure and temperature could be established and a new value for Q (equation 5, page 6) could be determined and used to recalculate the value of $\log(1-M(t)/Q)$. As an example for $M(t)/Q = 0.5$, $\log (1-M(t)/Q) = -.301$, and for $M(t)/Q = .9$, $\log_{10}(1-M(t)/Q) = -1.0$. Therefore, the data at the nonequilibrium position where Q is assumed to be the value given after time t would give a diffusion coefficient proportional to 1/t while the system with $M(t)/Q=0.5$ has reached only 1/2 of its equilibrium weight loss and would give a diffusion coefficient proportional to 0.3/t or only 30 per cent of that derived from the nonequilibrium data.

2.5.2 ZrO_2-Nb_2O_5

The diffusion results reported for this system closely parallel those reported for the Cr_2O_3-Nb_2O_5 system. The diffusion coefficients determined using the logarithmic model (Figure 17) are scattered within a band, the trend being that the slowest diffusion occurs at 1000°C, an intermediate temperature. The diffusion results from the parabolic model (Figure 21) indicate a slower diffusion rate as the departure from stoichiometry increases. However, in this case, the large diffusion coefficient is associated with the highest temperature for each partial oxygen pressure region. The power dependence of oxygen weight loss on oxygen partial pressure (Fig. 25) shows a -1/6 power dependence at 850 and 1000°C and a -1/4.8 power dependence at 1175°C. The previous comments concerning intermediate phases do apply here also. Runs ZR-3 and ZR-6 have not reached equilibrium, accounting for the different power dependence at 850 and 1000°C.

2.5.3 Al_2O_3-Nb_2O_5

The chemical diffusion coefficients determined from both the logarithmic (Figure 18) and parabolic (Figure 22) models show a lower diffusion coefficient as the degree of nonstoichiometry decreases. The 1175°C diffusion coefficients determined by the parabolic model are smaller than those determined at 1000°C and 850°C. Figure 26 shows the degree of nonstoichiometry as a function of oxygen partial pressure. For this system, the deviation from stoichiometry is proportional to the -1/8.4 power of the oxygen pressure for 850 and 1000°C and to the -1/6.3 power of the oxygen partial pressure at 1175°C. These numbers are larger than can be rationalized for any common defect model and strongly supports the fact that suboxide phases are controlling the oxygen transport.

2.5.4 TiO_2-Nb_2O_5

In this system, the logarithmic model (Figure 19) shows the opposite effect of oxygen non-stoichiometry on the chemical diffusion coefficient than found for the other three oxide systems. The larger deviation from stoichiometry produces the most rapid oxygen transport through the oxide. The parabolic model, Figure 23, does not indicate any trend of the effect of non-stoichiometry on the diffusion coefficient as the values are scattered within the band designated. Figure 27 shows the dependence of nonstoichiometry on the oxygen partial pressure. At 850°C the degree of nonstoichiometry was dependent on the -1/8 power of the oxygen partial pressure. In the Phase II[2] final, at 819°C, the nonstoichiometric dependence was shown to be proportional to -1/20 power of the oxygen pressure. At the higher temperature, the pressure dependence is -1/4.2.

2.6 GENERAL DISCUSSION OF OXYGEN DIFFUSION IN MIXED NIOBATES

It is apparent that phase equilibrium data as a function of oxygen partial pressure and binary oxide composition is required to fully interpret the experimental results presented. It is also apparent that, if new phases form as a function of oxygen partial pressure, a different set of boundary conditions for the diffusion model would have to be applied. Crank[19] presents a solution to the diffusion equation in which a moving boundary is passing through a system. In these oxides, this boundary would be the interface between two phases, one initially in equilibrium with a starting oxygen partial pressure and the second in equilibrium with the final oxygen partial pressure. As oxygen is removed from the system, this phase boundary proceeds through the oxide. This model, however, precludes the use of the integrated weight loss analysis which can be done using the weight loss technique. One has to know the oxygen concentration at the moving boundary as well as the oxygen concentration profile through each phase. Also, the solution will work only with a semi-infinite medium.

If one can determine the oxygen partial pressure-oxide phase equilibrium limits, then the diffusion measurement can be made within a single phase. Should the multi-phase suboxide structures be a reality in the oxides studied, the parabolic model would possibly give a better indication of the diffusion rate through a given equilibrium structure because of the short initial time period over which the model is valid.

3.0 OXIDATION BEHAVIOR OF NIOBIUM INTERMETALLIC COMPOUNDS

Work has been reported on the relative oxidation resistance of some niobium intermetallic compounds [20-22]. One of the most oxidation resistant compounds was found to be $NbAl_3$. Other niobium based alloys have also been reported which exhibit the same low rate of oxidation as $NbAl_3$ [23-26]. However, not all of these alloys form the oxidation products formed by $NbAl_3$. From this limited information it was deduced that possibly other oxides formed from intermetallic compounds would be protective. In light of the lower oxygen transport rate through Nb_2O_5-Cr_2O_3 oxides determined during this program, a series of seven intermetallic compounds have been arc melted from pure metals. These as-melted buttons are shown in Figure 28. Table 2 lists the compounds and weight losses incurred during melting due to volatilization, loss of small chipped particles, etc. The buttons were melted twice, the second melting occurring after the buttons were flipped over in the molds to insure homogeneity.

The samples were oxidized in a Stanton Thermal Balance described in a previous report [2].

3.1 CHARACTERIZATION OF THE NIOBIUM INTERMETALLIC COMPOUNDS

The as-melted compounds were characterized by x-ray diffraction analysis and metallographic examination and hardness. Table 3 lists the phases identified in the as-melted compounds. $NbAl_3$, $NbCr_2$, $NbFe_2$, and $NbCo_2$ gave the best correlation to the respective ASTM data cards. Table 4 lists the Vickers Hardness Numbers for the intermetallic compounds. The as-cast microstructures of the intermetallic compounds are shown in Figures 29-35 a and b at 75X and 500X, respectively. The structures, which resulted from annealing at the oxidation temperatures, can be seen in the photomicrographs of the respective samples showing the oxide structure.

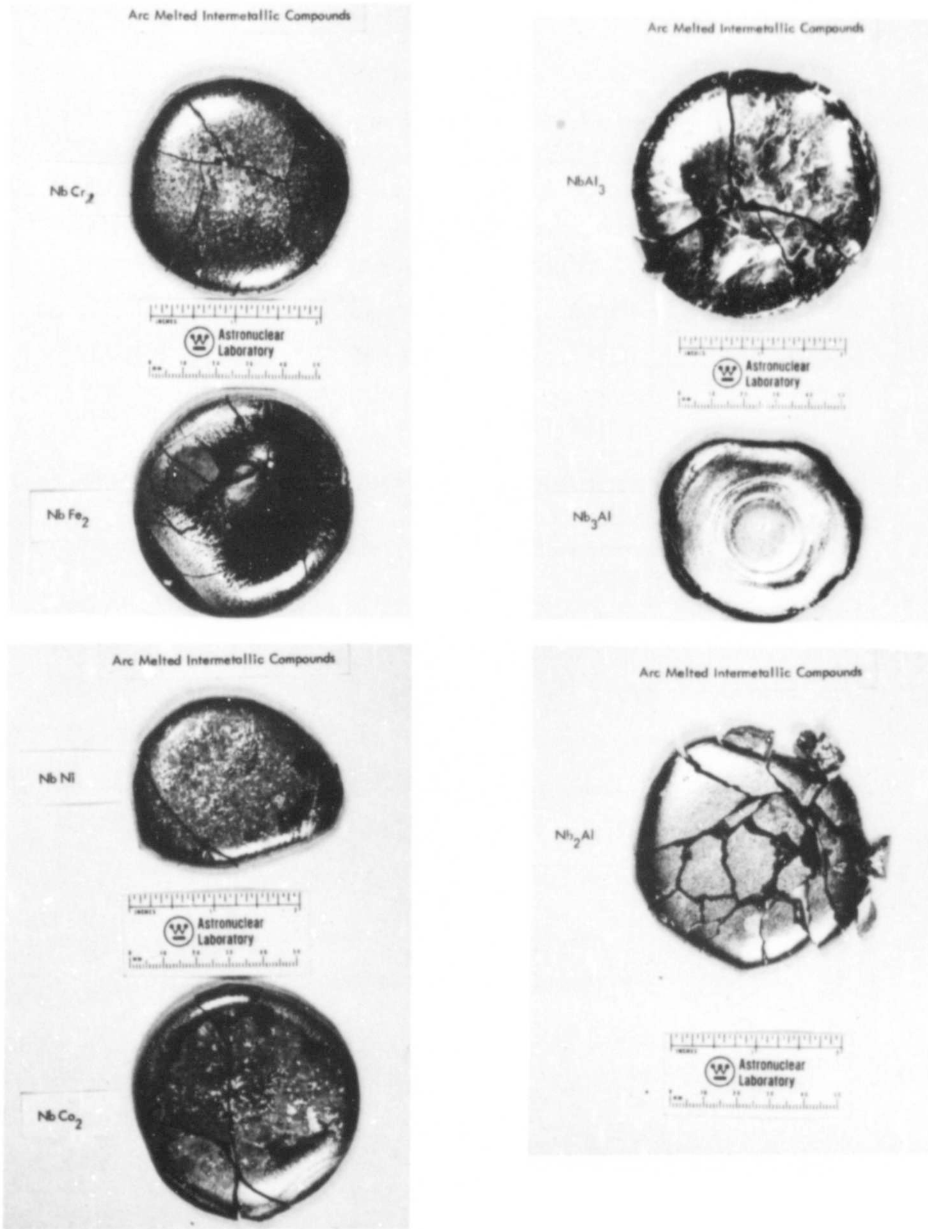


FIGURE 28

Arc-Melted Buttons of Nb Intermetallic Compounds
Showing As-Melted Condition

TABLE 2

Melting Information for Nb Intermetallic Compounds

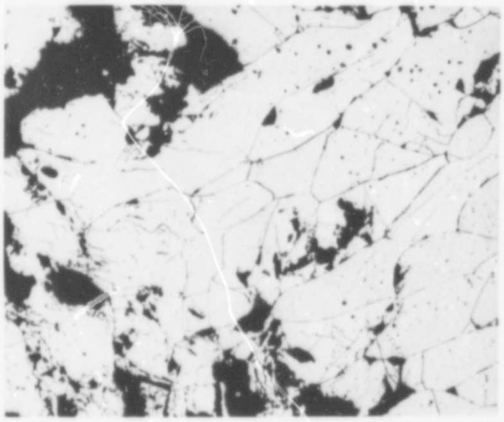
Compound	As-Melted Weight (gms)	Weight Loss During Melting (gms)	Melting Current (amps)
Nb_3Al	161.00	3.53	850-900
Nb_2Al	168.60	3.19	830-900
$NbAl_3$	184.77	2.36	750-800
NbNi	163.05	0.10	640-750
$NbCr_2$	210.79	1.14	625-600
$NbFe_2$	219.51	0.73	600-690
$NbCo_2$	225.96	0.77	600-730

Table 3. Results of the Debye X-ray Diffraction Analysis on the As-Melted Intermetallic Compounds (Siemens 114 mm camera, Cu_K radiation) (Phases listed in order of importance)

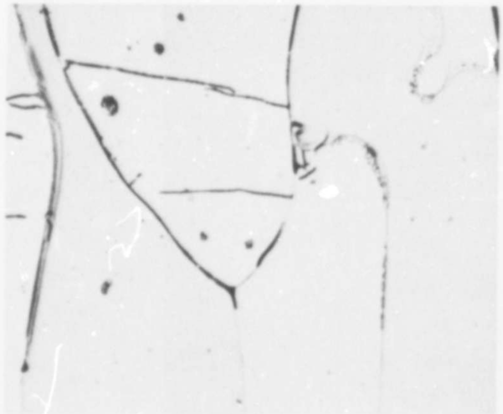
Compound	Phases Identifies	ASTM Card No.
$NbAl_3$	Tetragonal Al_3Nb (good match)	13-146
Nb_2Al	Tetragonal AlNb Tetragonal $AlNb_2$ Cubic $AlNb_3$ (many lines found)	14-458 15-598 12-85
Nb_3Al	Not determined	
$NbCo_2$	Cubic Co_2Nb (good match)	15-499
$NbFe_2$	Hexagonal Fe_2Nb Hexagonal Fe_5Nb_3 (several very weak lines)	17-908 12-590
$NbCr_2$	Cubic Cr_2Nb + Some hexagonal Cr_2Nb	5-0701
NbNi	Tetragonal NbNi } good Hexagonal NbNi } match to both cards + Orthorombic $NbNi_3$	16-447 15-268 15-101 & 17-700

Table 4. DPH Hardness Values for As-Melted Intermetallic Compounds

	DPH	Load (kg)
$NbAl_3$	384	10
Nb_2Al	640	30
Nb_3Al	718	30
$NbCr_2$	753	20
NbNi	516	30
$NbFe_2$	706	20
$NbCo_2$	881	30

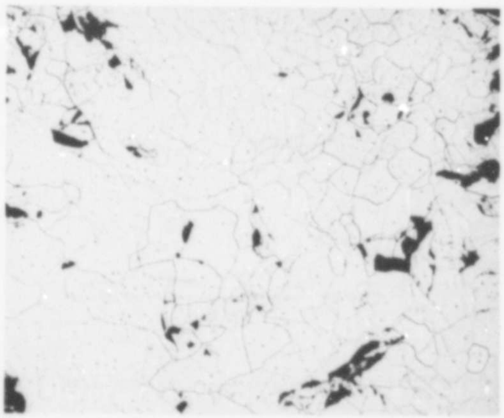


24547 (a) 75X

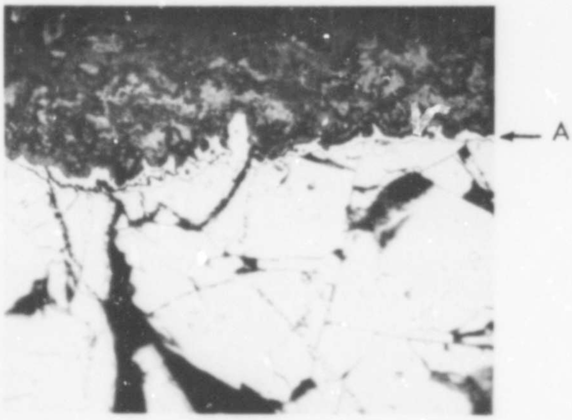


24547 (b) 500X

Microstructure of As-cast $NbAl_3$ (etched)



24589 (c) 75X



24589 (d) 500X

Microstructure of $NbAl_3$ Oxidized at 1200°C for 1000 minutes. (c) showing the grain formation as the result of annealing when compared to (a). (d) showing the structure of the oxidation products.

Figure 29. Microstructural Characteristics of $NbAl_3$ As-cast and After 1200°C 1000 min. Air Oxidation Exposure

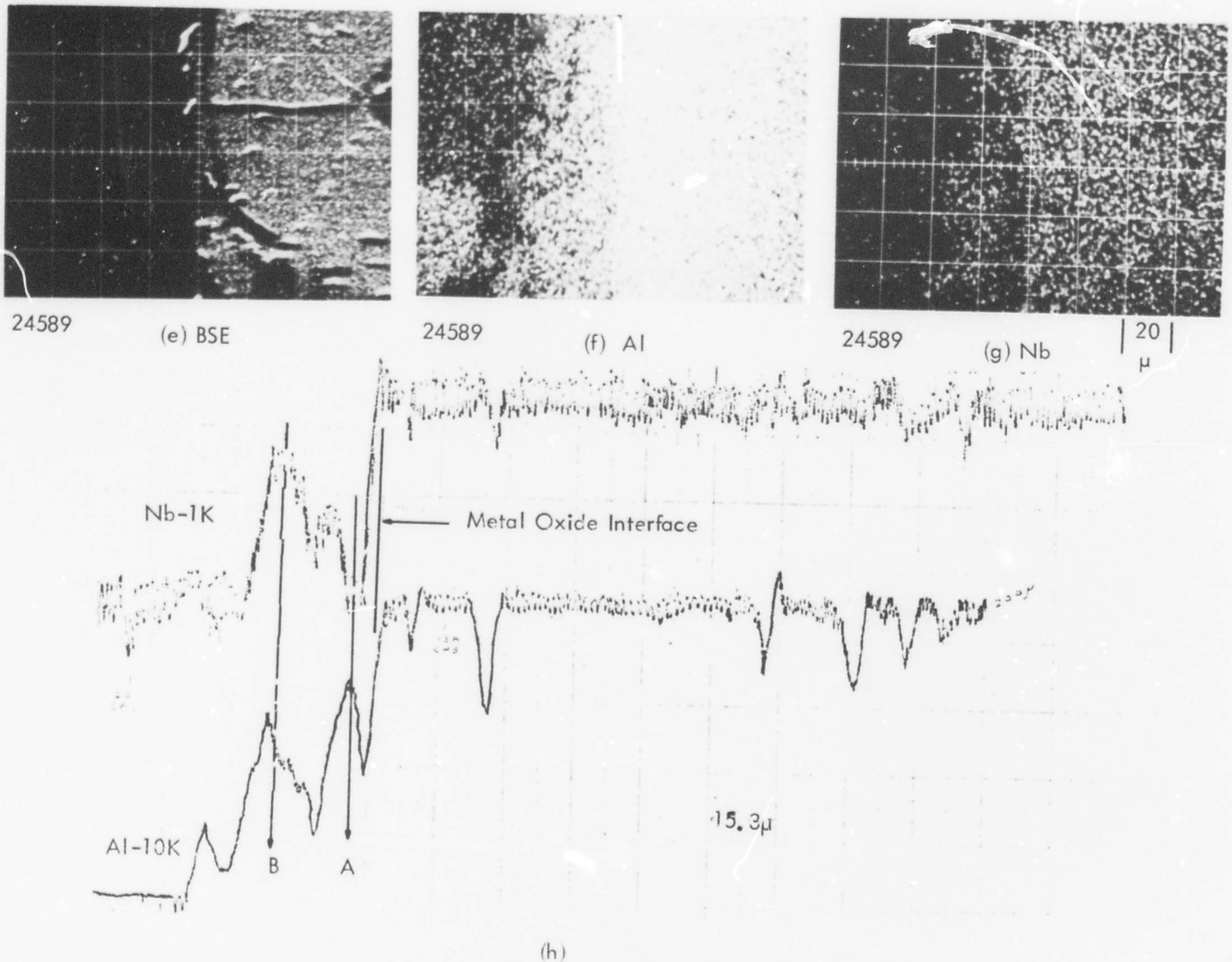
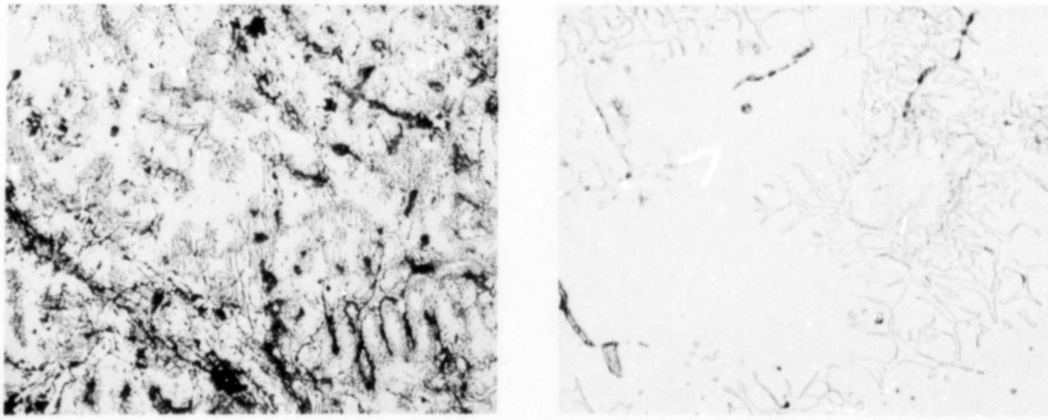
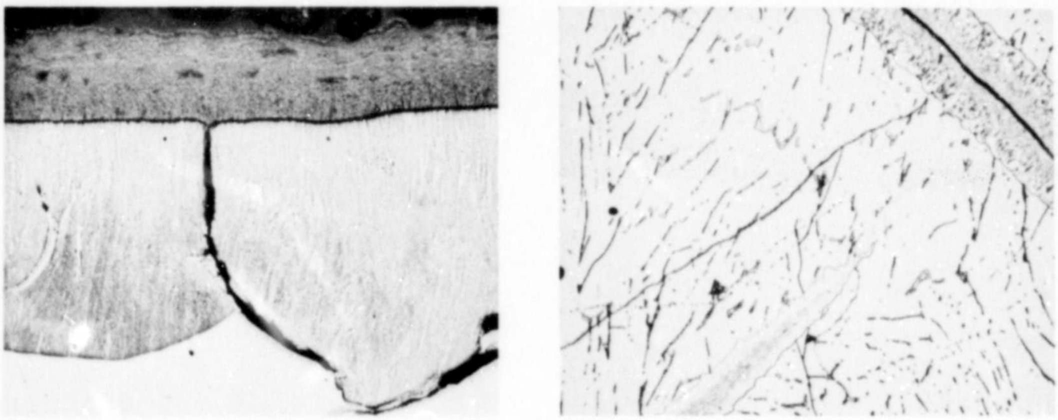


Figure 29 (e-h). Results of Microprobe Examination of $NbAl_3$



24548 (a) 75X 24548 (b) 500X

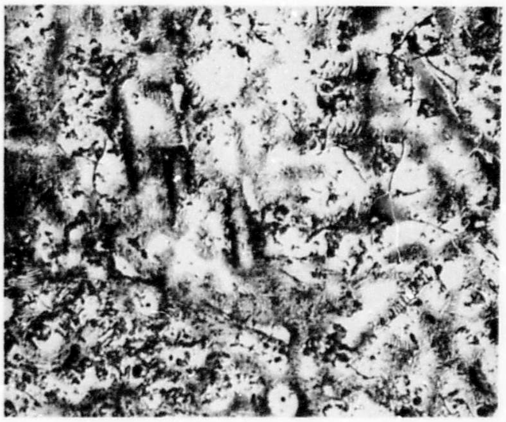
Microstructure of As-cast Nb_2Al (etched)



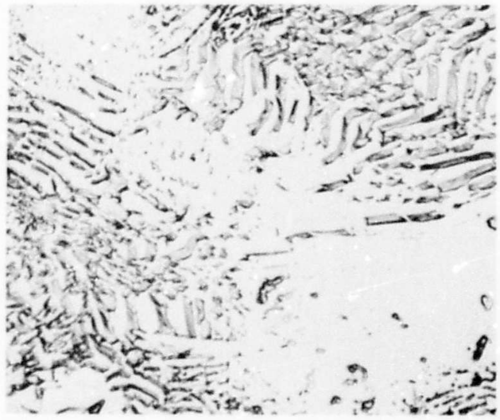
24586 (c) 75X 24586 (d) 500X

Microstructure of Nb_2Al Oxidized at 1200°C for 769 min. (c) showing the several thick oxide layers formed and (d) showing internal oxidation resulting from oxygen transport through cracks in the material.

Figure 30. Microstructural Characteristics of Nb_2Al As-cast and After 1200°C 769 min. Air Oxidation Exposure

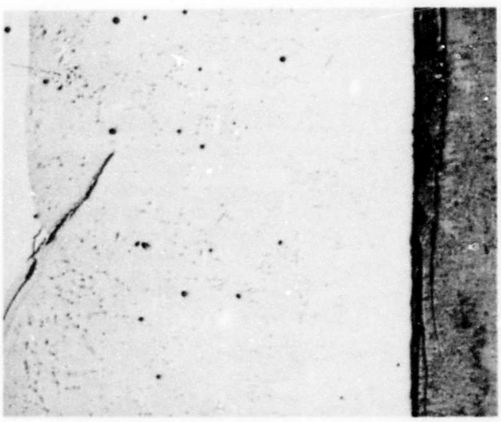


24549 (a) 75X

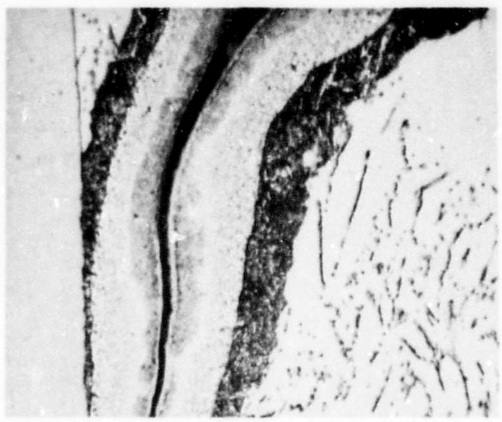


24549 (b) 500X

Microstructure of As-cast Nb_3Al (etched)



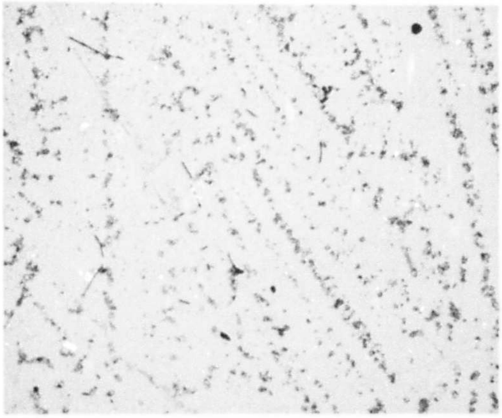
24585 (c) 75X



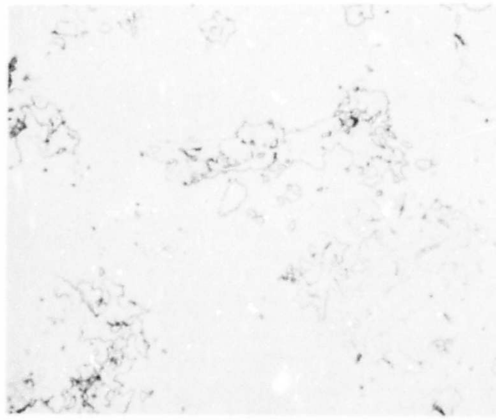
24585 (d) 500X

Microstructure of Nb_3Al Oxidized at 1200°C for 736 min. (c) showing the gross oxide layers formed, and (d) showing the oxidation at a matrix internal crack interface, the oxide facing left, and the matrix at the right.

Figure 31. Microstructural Characteristics of Nb_3Al As-cast and After 1200°C, 736 min. Air Oxidation Exposure



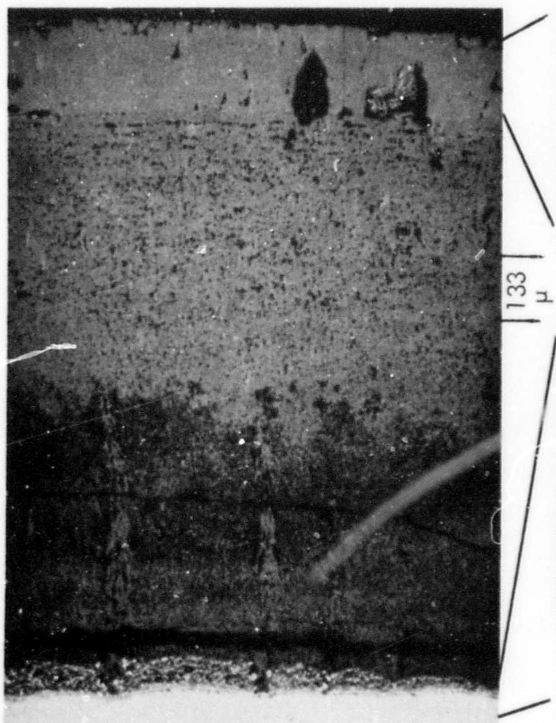
24550 (a) 75X

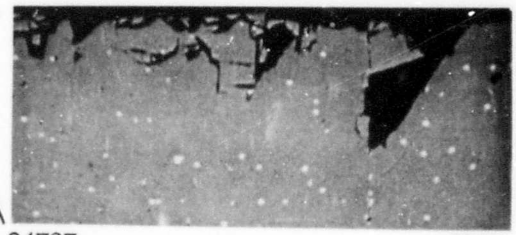


24550 (b) 500X

Polished and Etched

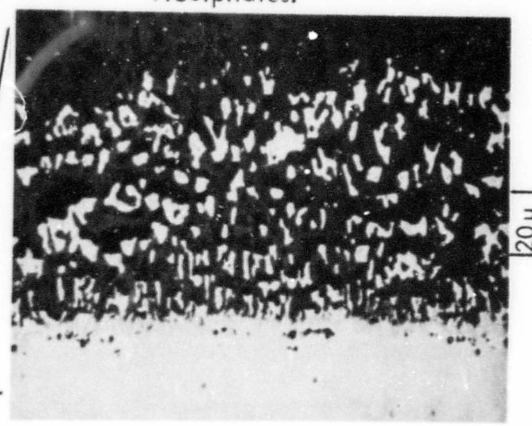
Polished and Etched





24727 (d) 500X

Glassy Surface Layer Showing Co Metal Precipitates.



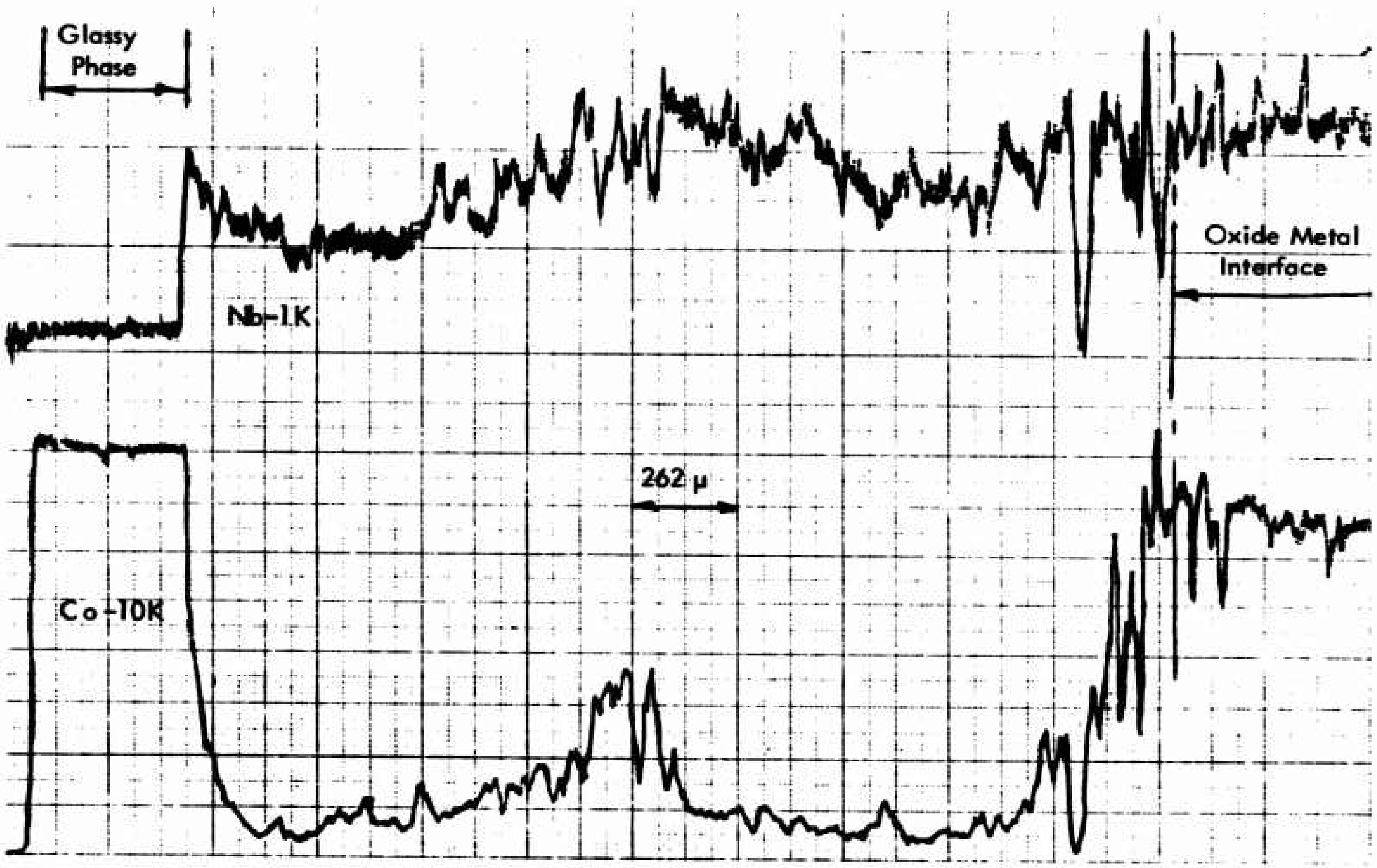
24727 (c) 75X

Oxide Scale

24727 (e) 500X

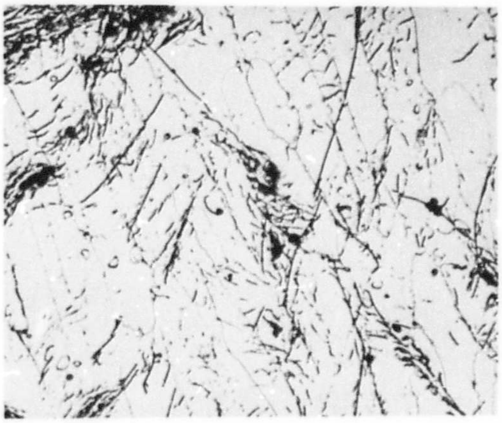
Oxide Metal Interface

Figure 32. Microstructure, Oxide Scale, and Elemental Distribution for $NbCo_2$ After Air Oxidation at 1200°C for 963 Minutes



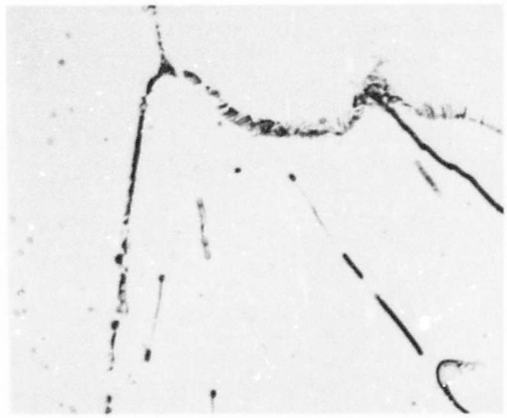
(f)

Figure 32f. Elemental Electron Microprobe Scans of Nb and Co Through the Oxide Scale



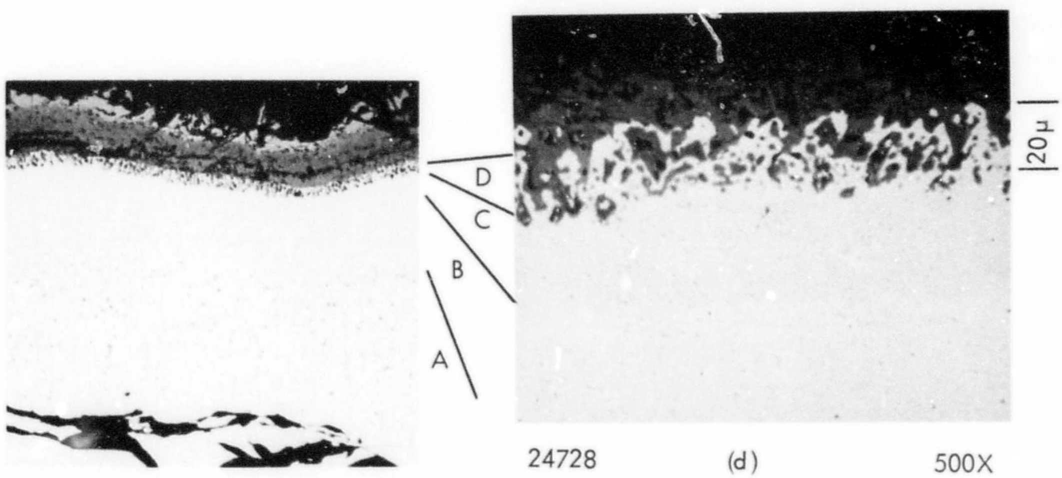
24552 (a) 75X

Polished and Etched



24552 (b) 500X

Polished and Etched

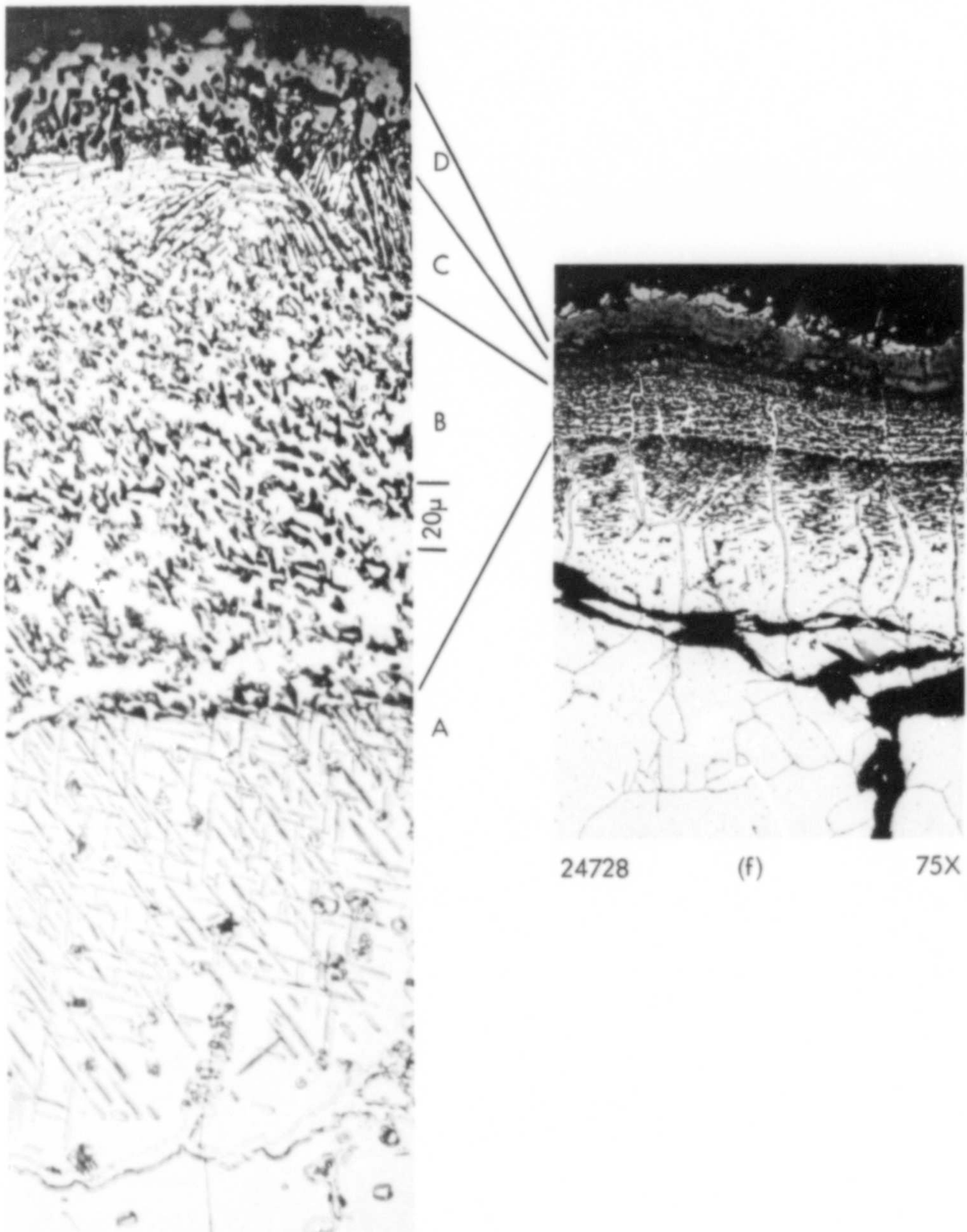


24728 (c) 75X

24728 (d) 500X

Oxide-Metal Interface

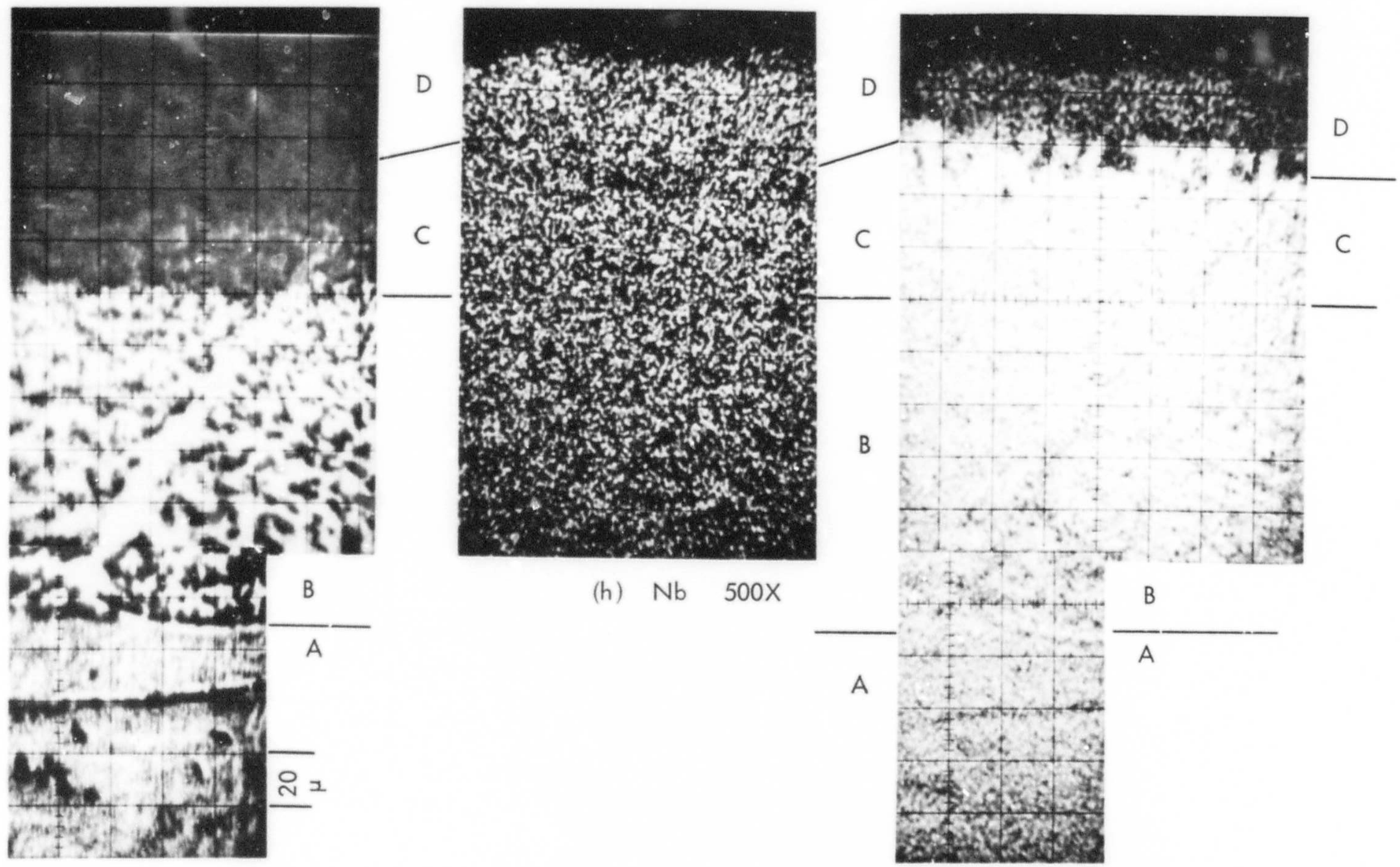
Figure 33. Microstructure, Oxide Scale, and Elemental Distribution for $NbFe_2$ After Air Oxidation at 1200°C for 1395 Minutes



24728 (f) 75X

24728 (e) 500X
Etched

Figure 33 (e-f)



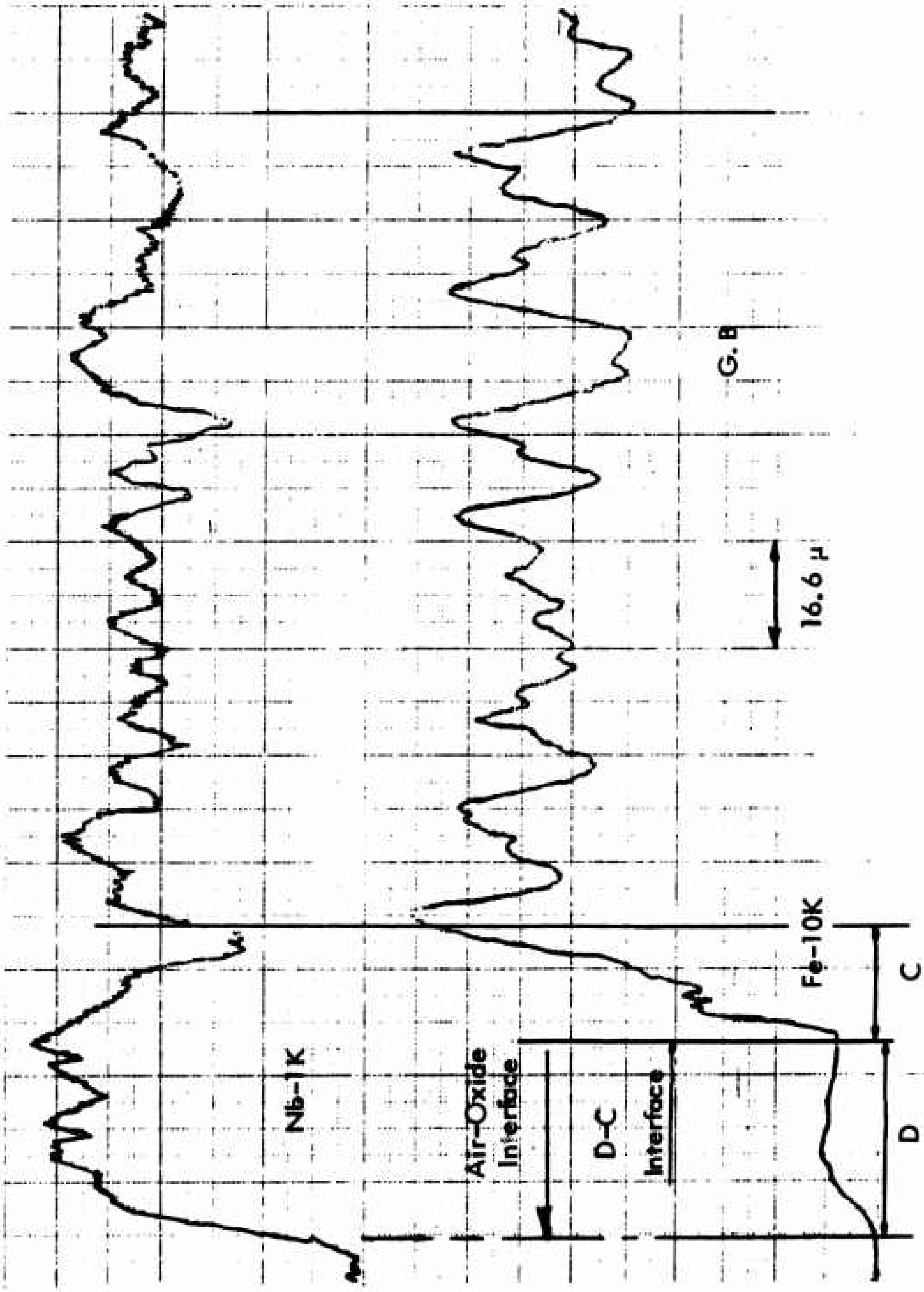
24728 (g) BSE

(h) Nb 500X

(i) Fe

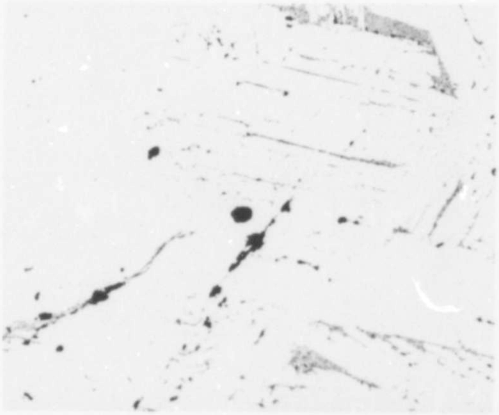
Astronuclear Laboratory

Figure 33(g--i). Composite Microprobe Photographs of $NbFe_2$

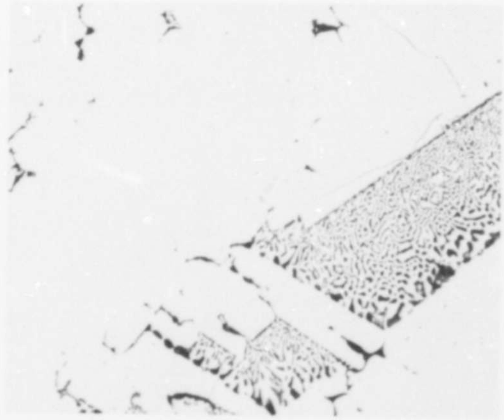


(j)

Figure 33j. Elemental Electron Microprobe Scans of Nb and and Fe Through the Oxide Scale

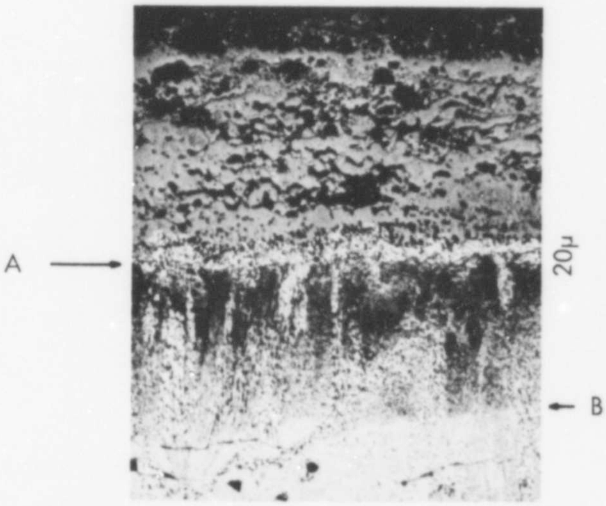


24551 (a) 75X



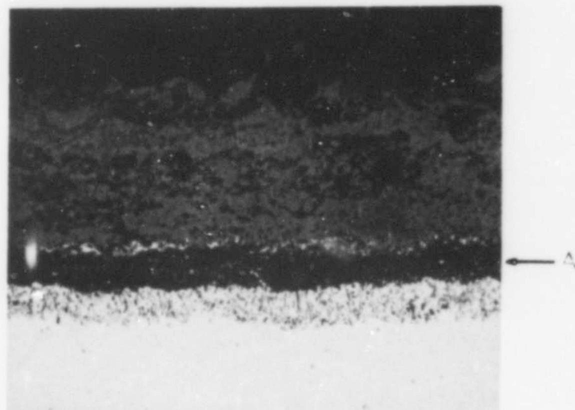
24551 (b) 500X

Microstructure of As-cast $NbCr_2$ (etched)



24587 (c) 500X

Electroetch

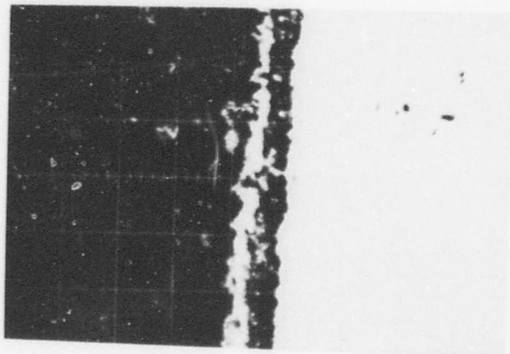


24587 (d) 500X

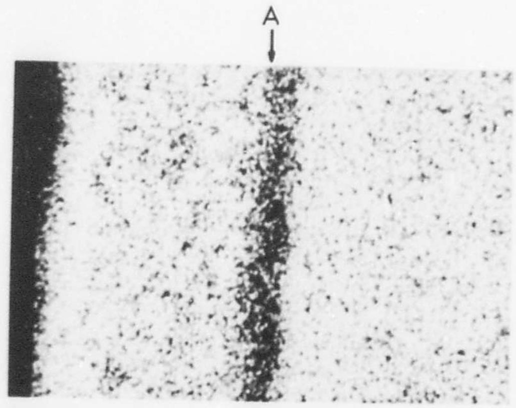
Acid Etched

Microstructure of $NbCr_2$ Oxidized at 1200°C for 860 minutes. (c) showing the discolored matrix band below the oxide, and (d) showing details across the oxide-metal interface.

Figure 34. Microstructural Characteristics of $NbCr_2$ As-cast and After 1200°C, 860 min. Air Oxidation Exposure

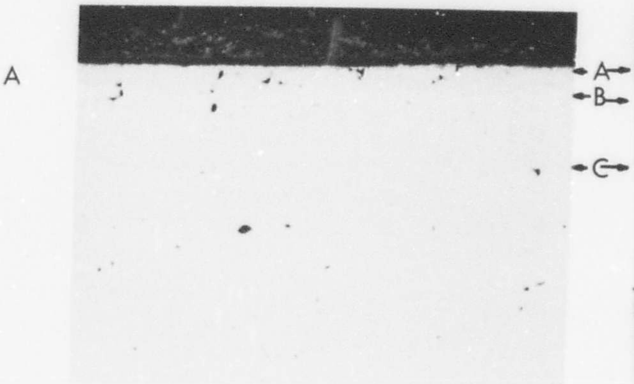


24587 (e) BSE |20 μ|



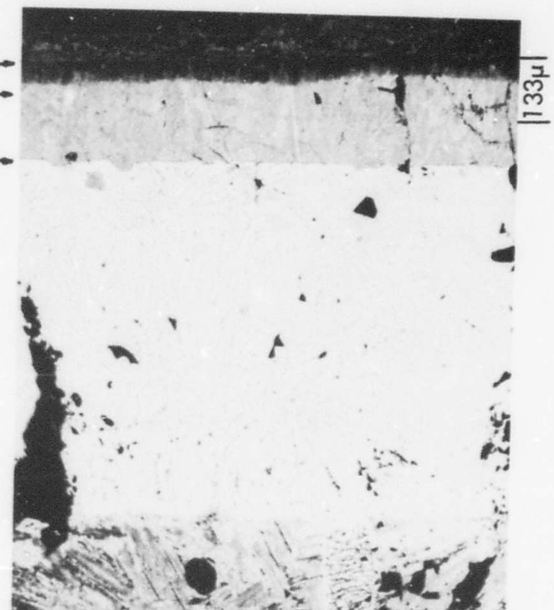
24587 (f) Cr

Electron Beam Microprobe Scans



24587 75X

(g) Unetched



24587 75X

(h) Etched

Figure 34 (Continued)

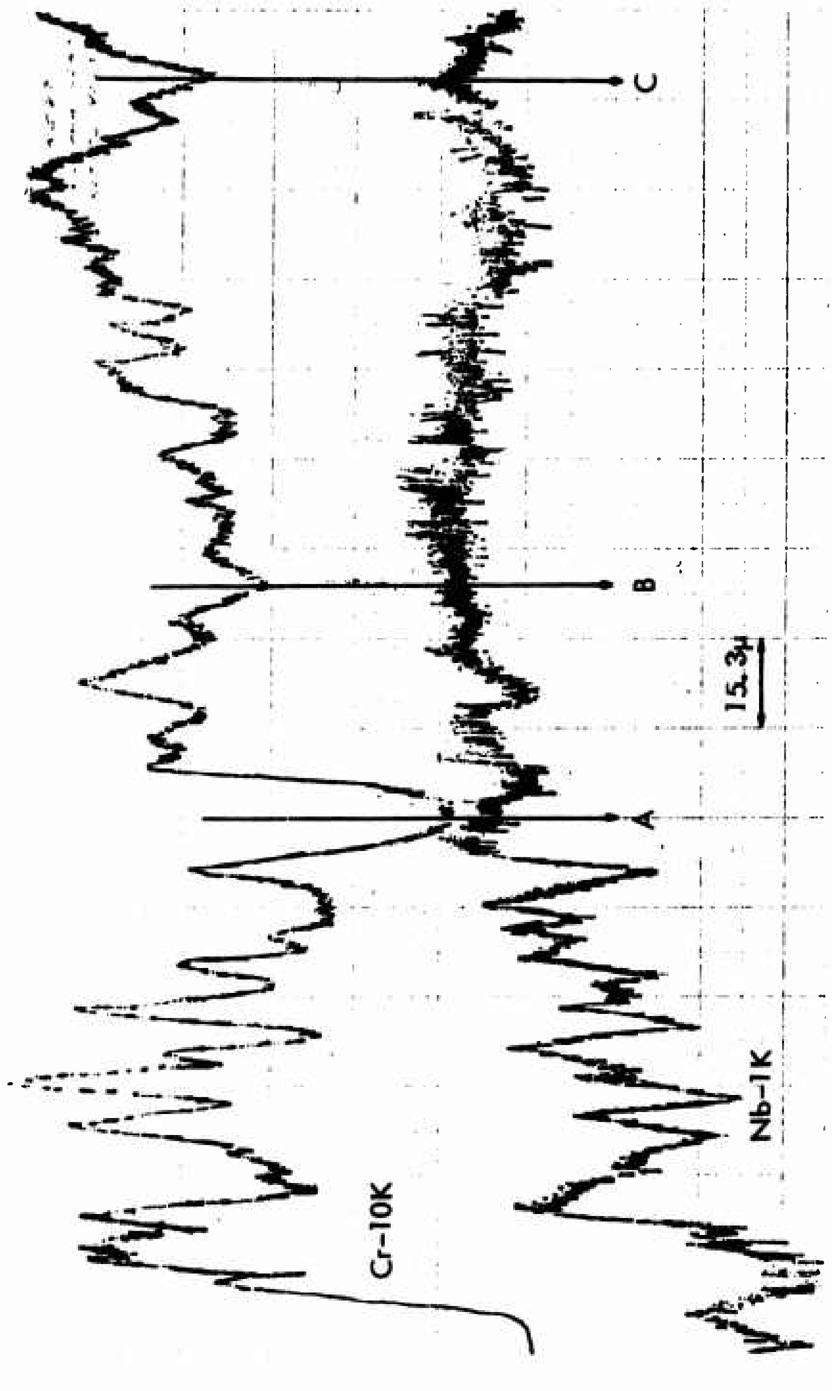
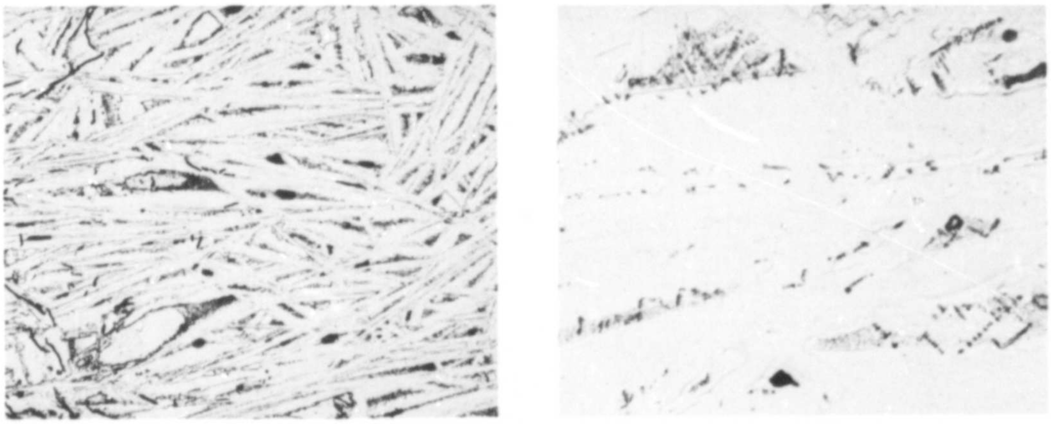
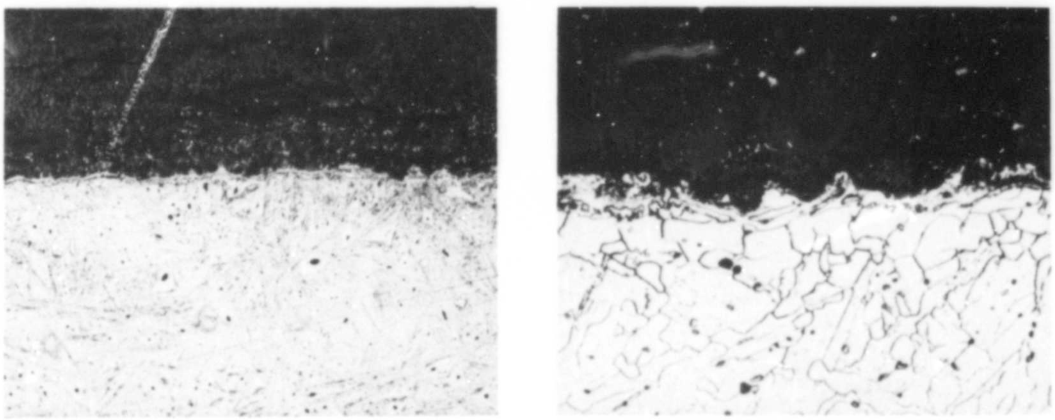


Figure 34(i). Microprobe Scan



24546 (a) 75X 24546 (b) 500X

Microstructure of As-cast NbNi (etched)



24588 (c) 75X 24588 (d) 500X

Microstructure of NbNi Oxidized at 1200°C for 252 min. (c) showing the oxide at the top, the oxide spotted with metallic particles, the interfacial phase, and the effect of temperature on the matrix. (d) showing details of the oxide-metal interface.

Figure 35. Microstructural Characteristics of NbNi As-cast and After 1200°C, 252 min. Air Oxidation Exposure

3.2 OXIDATION BEHAVIOR OF THE INTERMETALLIC COMPOUNDS

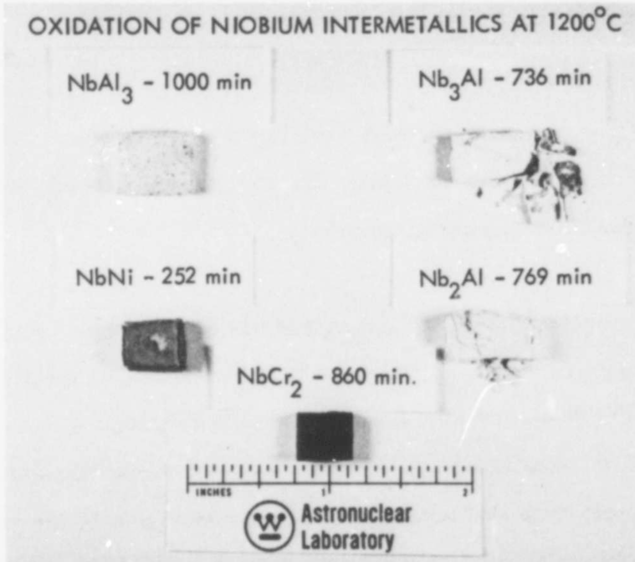
The seven intermetallic compounds were oxidized in air at 1200°C in the platinum thermal balance fumace. The arc-melted alloys were cut into rectangular solids for oxidation testing. The surface areas were measured, and the samples exposed for times up to 16 hours. The weight change was continuously recorded.

Figure 36 shows the intermetallic samples and oxides formed during oxidation at 1200°C. Figure 37 shows the weight loss per unit area for all of the intermetallic compounds. As previously reported, $NbAl_3$ exhibits the best oxidation behavior. However, $NbCr_2$ and $NbFe_2$ also exhibit good oxidation behavior and will be considered further. Nb_2Al, Nb_3Al, and NbNi all exhibited very poor oxidation behavior, large oxide zones, and gross sub-surface contamination. $NbCo_2$ exhibited a distinctive, different kind of behavior in that the surface oxide formed on the sample melted. The $NbCo_2$ sample in Figure 36 shows the glassy appearance of the oxide surface. Figure 38 shows the quantity $(\Delta M/A)^2$ vs t; the slope of this plot was used to calculate the parabolic rate constant. The parabolic rate or linear rate constants are listed in Table 5 where applicable. The linear rate constant was determined for Nb_2Al, Nb_3Al, and NbNi.

Photomicrographs of oxide scale-metallic interface sections are shown in Figures 29-35, and Table 6 lists the results of the x-ray diffraction analysis of oxide scales formed on the intermetallic compounds.

3.2.1 $\underline{NbAl_3}$

Figure 29(d) shows the oxide-metal interface at 500X. The x-ray diffraction analysis (Table 6) indicates the presence of the $NbAlO_4$ rutile structure in the oxide as well as Al_2O_3. The



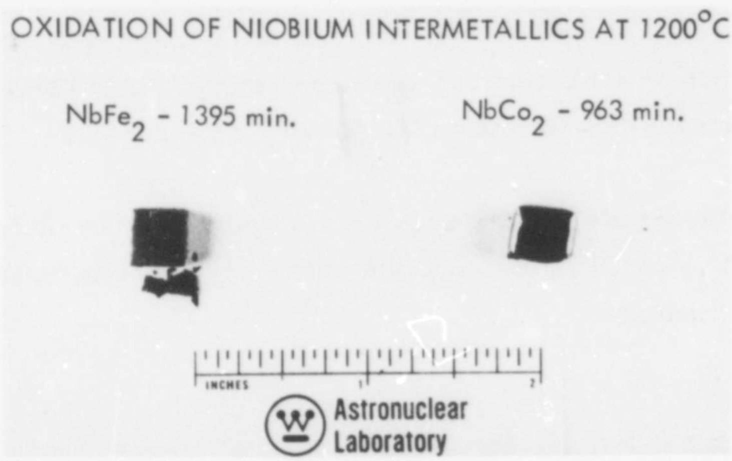


Figure 36. Photograph Showing the Results of 1200°C Air Oxidation of the Niobium Based Intermetallic Compounds

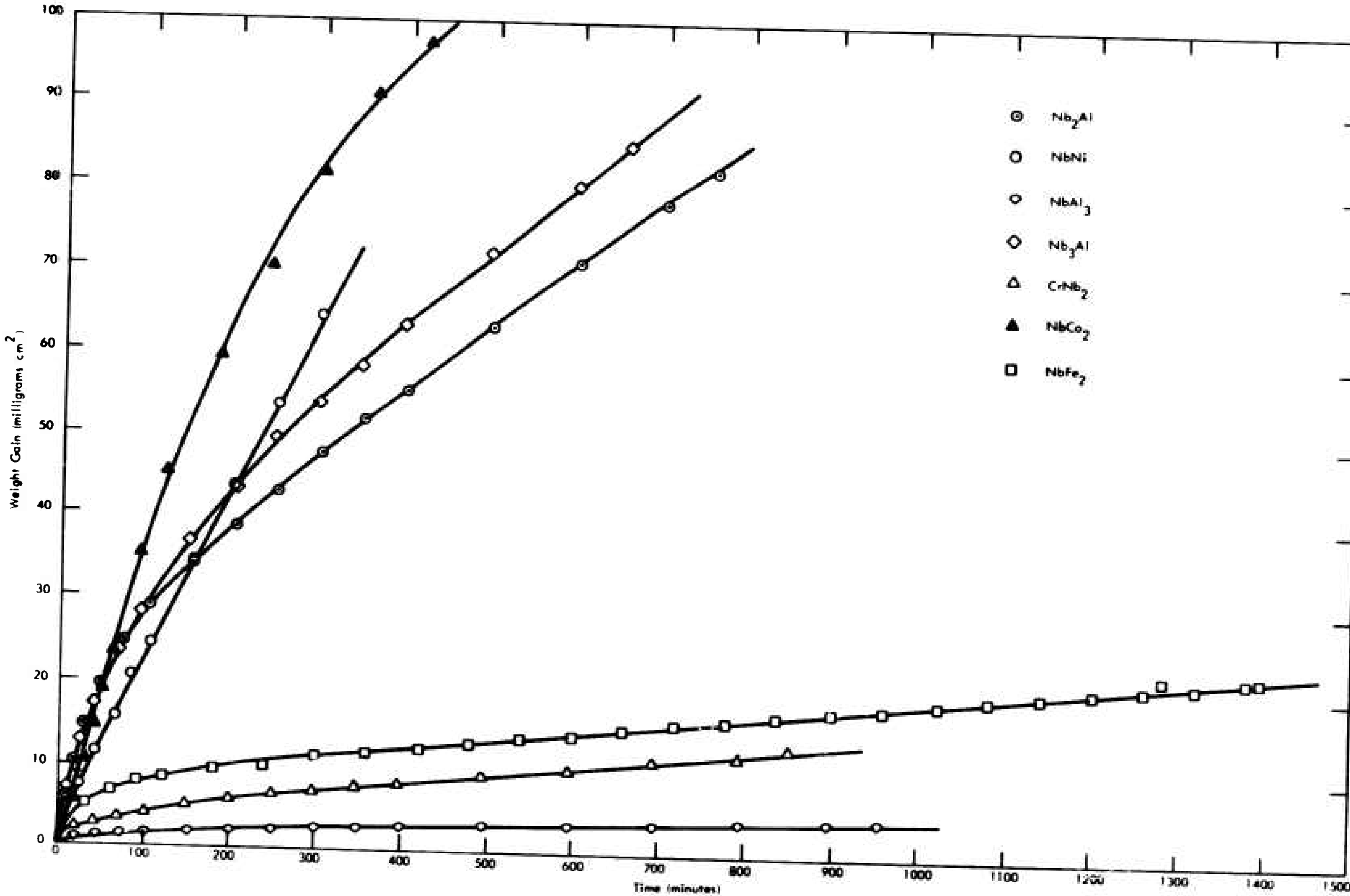


Figure 37. The Oxidation Kinetics of Niobium Intermetallic Compounds in Air at 1200°C

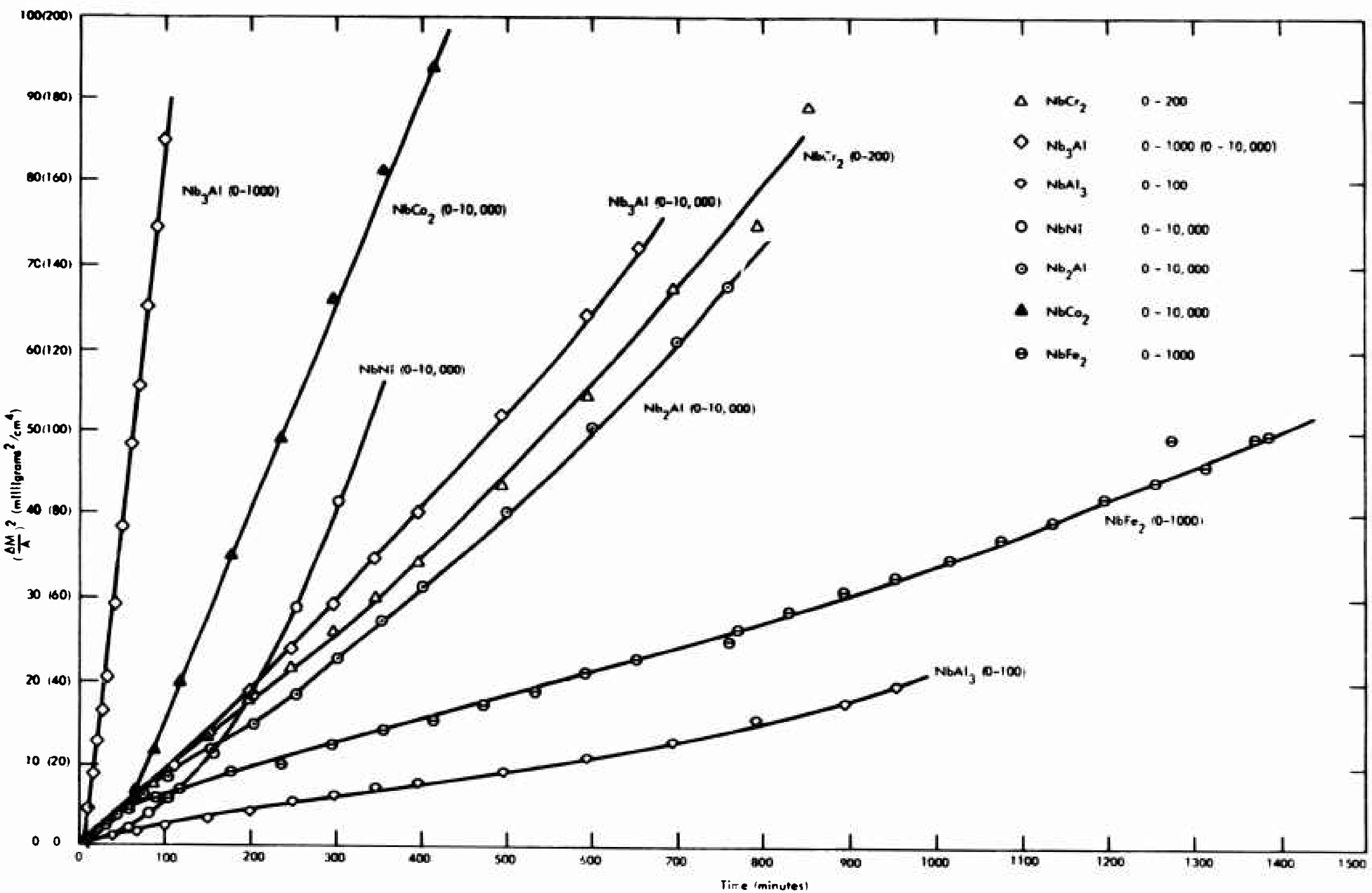


Figure 38. The Plot of $(\Delta M/A)^2$ vs Time for the Niobium Intermetallic Compounds in Air at 1200°C

Table 5. Rate Constants for Niobium Based Intermetallic Compounds at 1200°C

Intermetallic Compound	Parabolic Rate Constant ($mg^2/cm^4/min$)	Linear Rate Constant ($mg/cm^2/min$)
$NbAl_3$	0.018	--
Nb_2Al	--	0.073
Nb_3Al	--	0.084
$NbCr_2$	0.176	--
NbNi	--	0.202
$NbFe_2$	0.31	--
$NbCo_2$	25.00	--

Table 6. Results of Debye X-ray Diffraction Analysis of the Oxide Scales Formed on the Intermetallic Compounds (Siemens 114 mm camera Cu_K radiation)

Compound	Phases Identifies	ASTM Card No.
$NbAl_3$	$AlNbO_4$ $\alpha\ Al_2O_3$	14-494 10-173
Nb_2Al	$AlNbO_4$ Al_2O_3-$9Nb_2O_5$ Al_2O_3-$25Nb_2O_5$ Some Nb_2O_5 lines	14-494 16-545 16-546
Nb_3Al	Same as Nb_2Al, except that lines are sharper and stronger	
$NbCr_2$	$CrNbO_4$ Cr_2O_3	(20-311) (6-0504)
NbNi	$NiNb_2O_6$	(15-159)
$NbFe_2$	$FeNbO_4$ - tetragonal monoclinic orthorhombic orthorhombic Some Fe_2O_3	16 - 357 16 - 374 16 - 358 15 - 596
$NbCo_2$	$Nb_2Co_4O_9$ - hexagonal (Matched also some $NbFeO_4$ cards)	13 - 464

microprobe results presented in Figure 29(e-h) show the distribution of niobium and aluminum through the scale-metal interface. The Al_2O_3 scale layer forms adjacent to the metal oxide interface, see A on Figure 29(h) and Figure 29(d). In this region, the niobium concentration appears to be down to the base line count. The $NbAlO_4$ portion of the scale is concentrated in the gray oxide region, presumably at the area labeled B in Figure 29(h). Berkowitz-Mattuck and Rossette[21], report that above 900°C, the protective barrier on $NbAl_3$ was found to be the Al_2O_3 layer. Additional work would be necessary to determine if the formation of $NbAlO_4$ is due to the elevated temperature exposure.

3.2.2 $NbCr_2$

The next most promising intermetallic was $NbCr_2$ shown in Figure 34. Two separate views of the oxide metal interface are shown. Figure 34(d) and (g) show the results of acid etching in Hf-HNO_3-H_2O at 500X and 75X, respectively. Figure 34(c-h) shows the structure revealed by an electroetch technique. The electroetch technique reveals several affected layers not revealed by the acid etch technique. The microprobe results, Figure 34(e, f, i) reveal compositional discontinuities. The region A on Figure 34(g) shows an area almost completely depleted in Cr. Figure 34(d) shows the same area, and it is grossly over etched. This depleted zone is continuous across the surface of the sample as is shown in Figure 34(f), a photograph of the Cr composition across the sample cross section. The chromium composition also has minimum at B about 30μ below the grossly depleted zone. There seems to be another steady increase in chromium composition until another depression in the composition curve occurs at C about 120μ, which is in the region C-B, Figure 34(g and h). The x-ray diffraction analysis of the oxides indicates both $CrNbO_4$ and Cr_2O_3 phases. This is analogous to the two phases found in the $NbAl_3$ intermetallic oxidation products. However, from the data presented, the position of the Cr_2O_3 layer is not readily identified. By virtue of the Cr peak in Figure 34(g) and the increased intensity of Cr shown in Figure 34(g), the Cr_2O_3 appears to be located at the oxide-gas interface rather than at the oxide-metal interface as was found for the $NbAl_3$ intermetallic.

3.2.3 $NbFe_2$

Figure 33 (a-g) shows the microstructures of the as-cast and oxidized $NbFe_2$ intermetallic after exposure at 1200°C. Figure 33(c) shows the as-polished structure at 75X. Note the two different gray tones on the oxide scale with the light outer surface layer. Figure 33(d) is an enlarged view of the oxide-metal interface at 500X. Figure 33(e) and (f) are 500X and 75X views of the oxide-metal interface in the etched condition. Four major zones are defined in this photomicrograph (A, B, C, D). Figure 33(g-j) shows the results of the electron microprobe study of this oxide metal interface. This trace includes zones D, C, and part of B. Nb is initially oxidized preferentially leaving an iron rich layer at the C-D interface. Zones B and C exhibit some gross phase separation. It appears that the light areas in Figure 33(g) in the backscattered electron mode are the Nb rich areas thus corresponding to the non-etched areas on Figure 33(e). In this figure zone A appears to have Fe precipitating out on definite crystallographic planes or selective internal oxidation occurring causing the precipitation of an oxide product which is preferentially etched away. There does appear to be a large internally oxidized zone in this alloy. Fe_2O_3 was also found in the oxide scale. From the results obtained, it is not possible to determine if Fe_2O_3 is formed as a protective layer. However, at C there does appear to be a region devoid of Nb and rich in Fe.

3.2.4 $NbCo_2$

Although at 1200°C $NbCo_2$ was not oxidation resistant, the oxide scales formed are quite interesting. The intermetallic $NbCo_2$ after oxidation exhibited a glassy exterior which did not crack on cooling. The streamline shape of the sample strongly indicates that a liquid phase surface compound was formed during oxidation. Shunk[27] reports that the Nb-Co eutectic at 85.5 a/o Co melts at 1210 ± 10°C. The microprobe scan (Figure 32) shows the glassy phase to consist of predominantly Co. Figure 32(d) shows a 500X enlargement of the glassy phase showing metallic Co spheroids in the matrix. It appears as if the glassy phase forms after some initial oxidation occurs. The oxidation kinetics in Figure 37 and Figure 38

show that initially a rapid linear weight gain occurs followed by oxidation at a decreasing rate approaching a straight line in Figure 38 indicating that a diffusion process through the scale began to control the oxidation rate. The microprobe trace shows that Nb is apparently rejected back into the oxide scale immediately below the glassy surface.

3.2.5 NbNi, Nb_2Al, Nb_3Al

These compounds were not oxidation resistant. Figures 35(c-d), 30 (c-d), 31 (c-d) show the massive oxide phases formed on NbNi, Nb_2Al, and Nb_3Al, respectively. Table 6 indicates that for these three compounds as well as for $NbCo_2$, oxide structures such as Al_2O_3-$9Nb_2O_5$, Nb_2O_5, $Nb_2Co_4O_9$ (hematite), and Nb_2NiO_6 (columbite) were formed. In contrast, on the compounds which exhibited good oxidation behavior, the $BNbO_4$ (rutile) - B_2O_3 (hematite) oxide structures were found, where B = Cr, Al, or Fe.

4.0 OXIDATION BEHAVIOR OF EXPERIMENTAL NIOBIUM ALLOYS

4.1 ALLOY PREPARATION AND CHARACTERIZATION

Five alloys whose compositions are shown on Table 7 were prepared from pure starting materials including arc melted Nb and electro-refined Cr. The alloy constituents were weighed and then arc-melted into buttons using a tungsten-arc button melting furnace. The buttons are shown in Figure 39. On cooling, the alloys were cut into regular shapes for oxidation testing using a diamond impregnated saw. The alloys were pulverized and subjected to x-ray diffraction analysis. Positive identification was very difficult due to the numerous lines, the overlapping, and the lack of any matching data in the card files for these compounds. Table 7 indicates the identifiable phases but is in no way inclusive or completely characteristic of the alloy.

The microstructures of the as-cast alloys are shown in Figures 40-44 (a and b). The Vickers hardness numbers are given in Table 8.

Area scans for elemental segregation were made for all of the alloys in the as-melted condition to determine the elements contained in the various phases shown in the photomicrograph and to possibly correlate this with the x-ray analysis of the as-melted alloy.

Alloys DU-1, DU-2, and DU-3 did not show any elemental segregation in the as-cast form. DU-4 and UC-5 did show phase segregation, and these area scans are shown in Figures 43 (h-l) and 44 (d-g). For DU-4, the light patches shown in the photomicrographs are basically Nb-Al compounds depleted in Fe. The matrix phase contains the Nb-Fe-Al constituents of the alloy.

The light phases in the alloy UC-5 are depleted in Fe as was the case for UC-4. They appear to be a Nb phase with small quantities of Ti present. The matrix appears to be an Fe-Ti rich phase depleted in Nb.

Table 7. Results of the Debye X-ray Diffraction Analysis on As-melted Niobium Based Alloys

Alloy **	Phases Identified*	ASTM Card No.
DU-1 **	Matches closely the lines for $NbCr_2$ with a lattice parameter change.	
DU-2 **	Film more closely matches NbNi with lattice parameter change	
DU-3 **	Same as above	
DU-4 **	Nb_3Al NbAl	12 - 85 14 - 458
UC-5 **	Nb-Fe Ti-Nb	20 - 1142 17 - 102

* Identification is difficult due to numerous lines and overlapping and the lack of matching data for these compounds.

** Alloy compositions in weight percent

DU-1	Nb-19Cr-10Al-15Co
DU-2	Nb-10Cr-10Al-15Ni
DU-3	Nb-9Cr-10Al-25Ni
DU-4	Nb-10Fe-19Al
UC-5	Nb-20Fe-15Ti-.5B

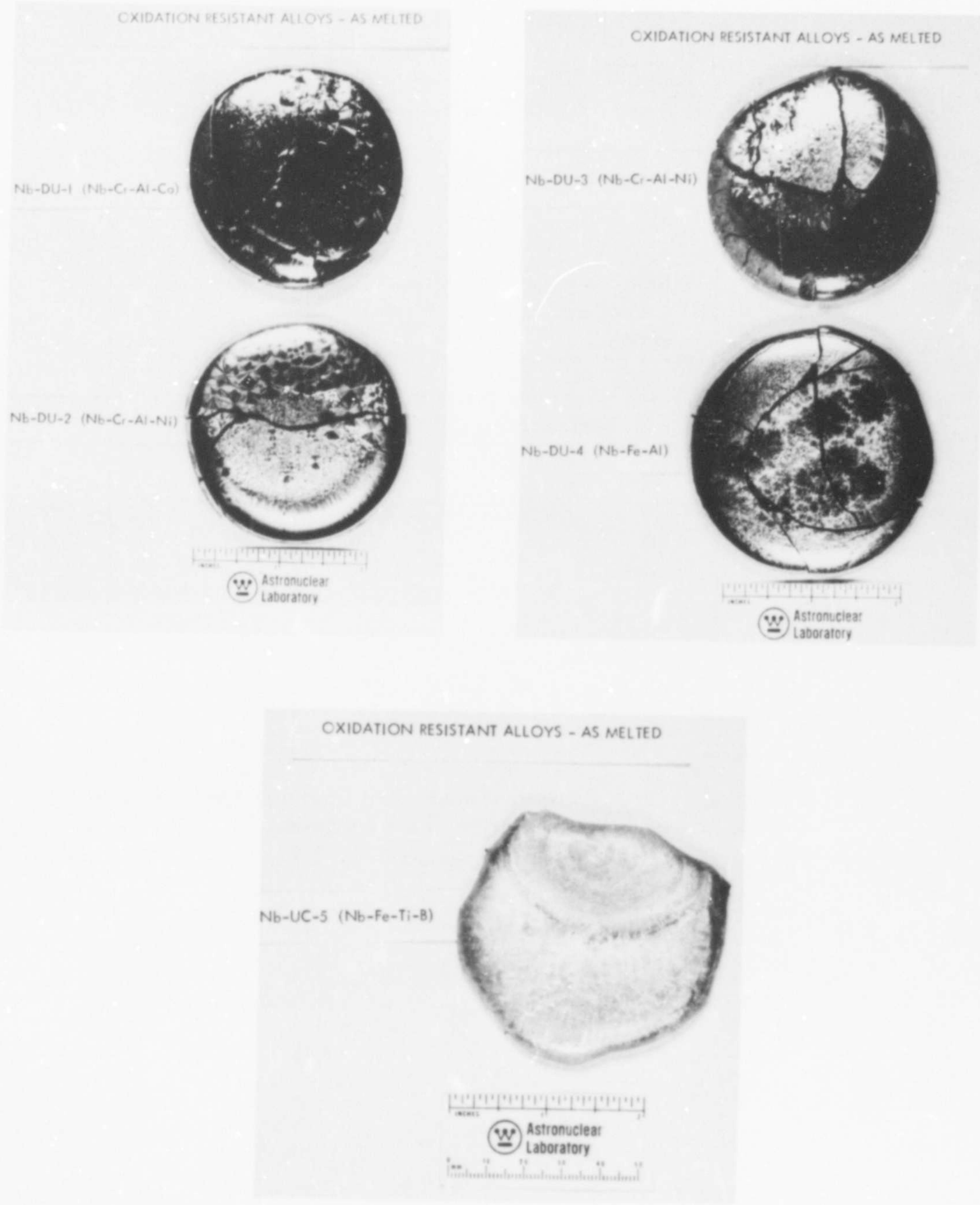
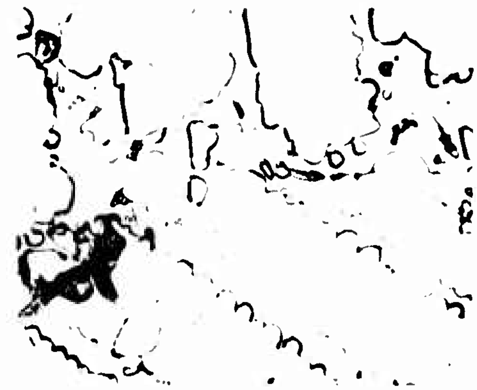
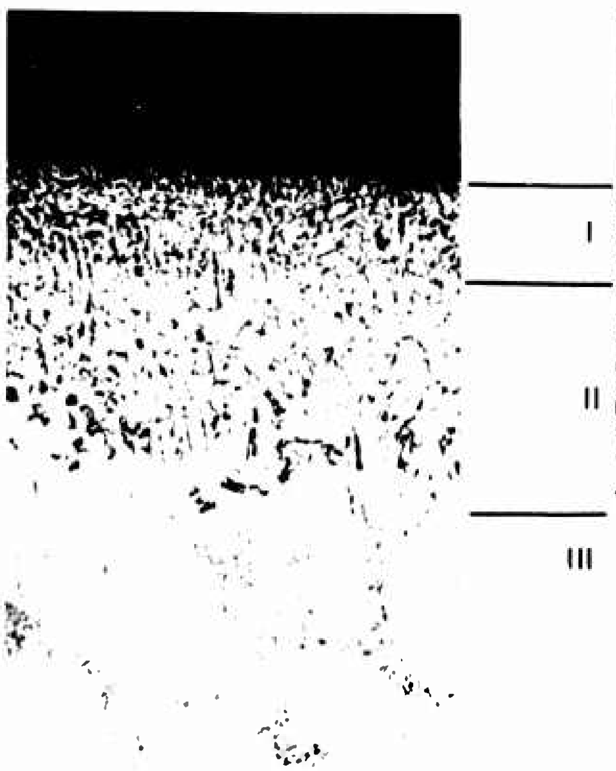


Figure 39. As-melted Buttons of Dupont and Union Carbide Oxidation Resistant Alloys

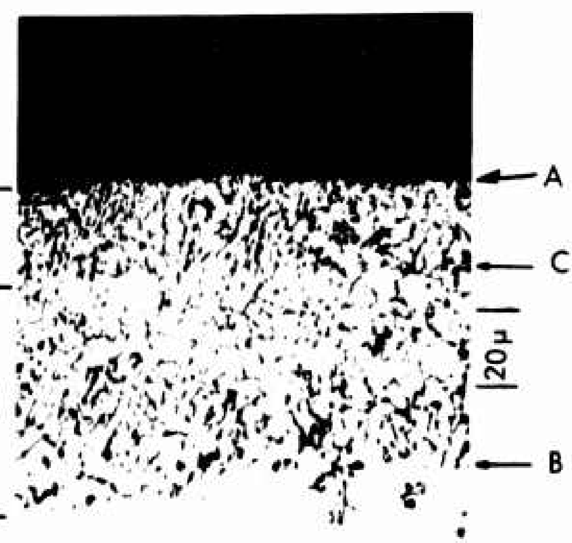
24509 (a) 75X
Polished and Etched



24509 (b) 500X
Polished and Etched



24710 (c) 500X
Oxidation Zone
(etched)



24710 (d) 500X
Oxidation Zone (unetched)

Figure 40. Microstructure, Oxide Scale, and Elemental Distribution for the Alloy Nb-19Cr-10Al-15Co (DU-1) After Air Oxidation for 1456 Minutes

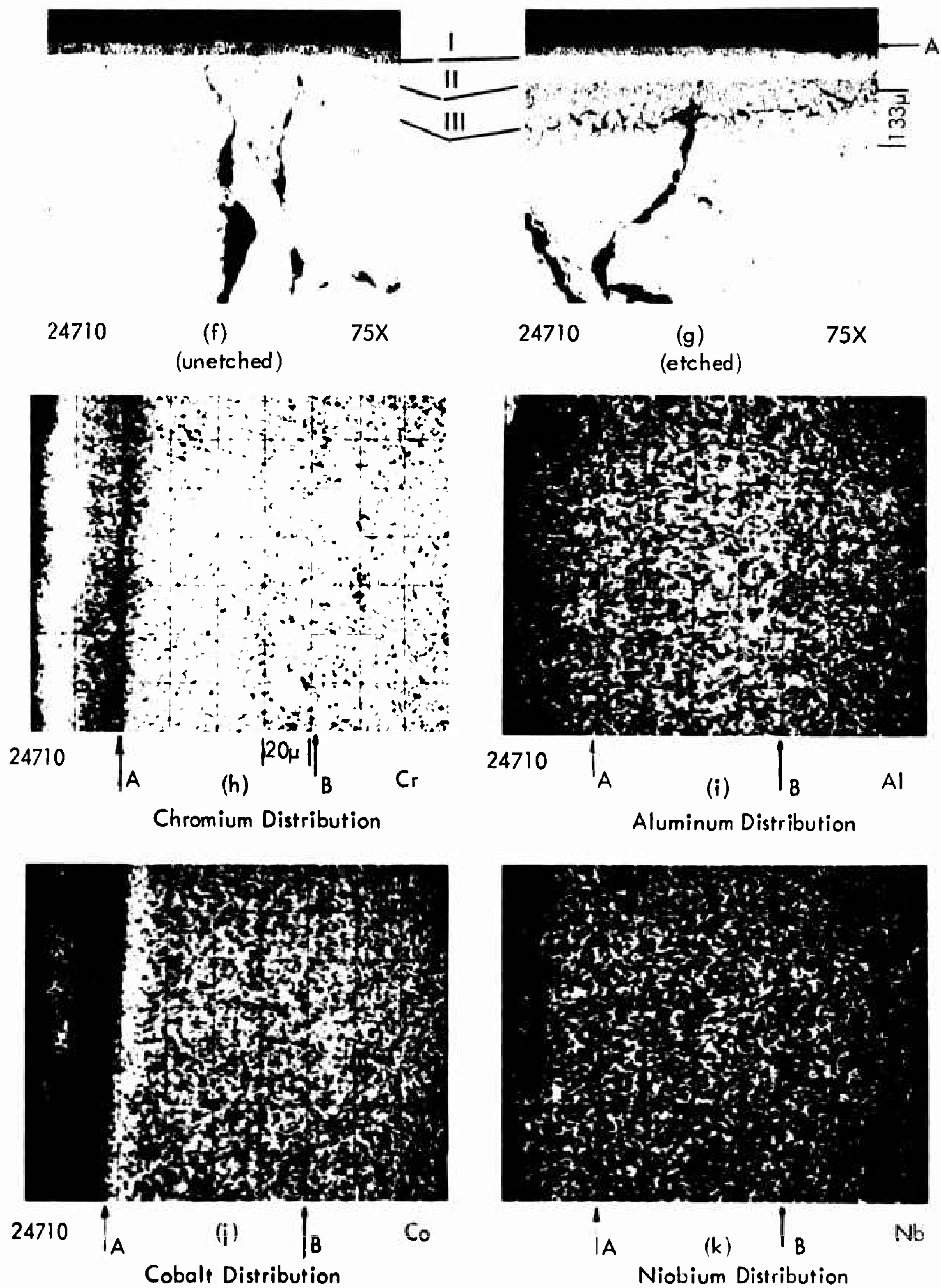


Figure 40 (f-k). Microprobe Photographs Showing Elemental Distribution

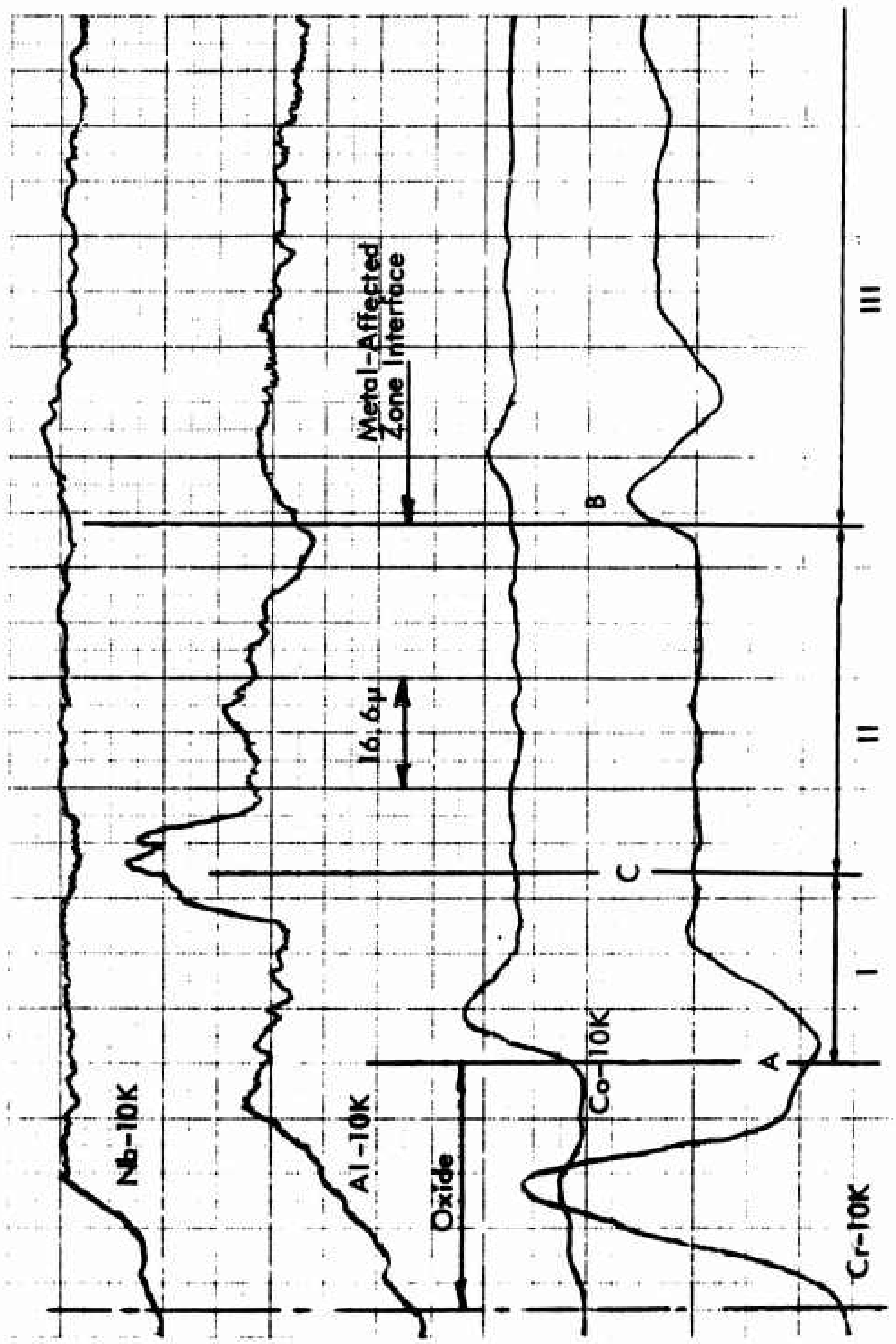
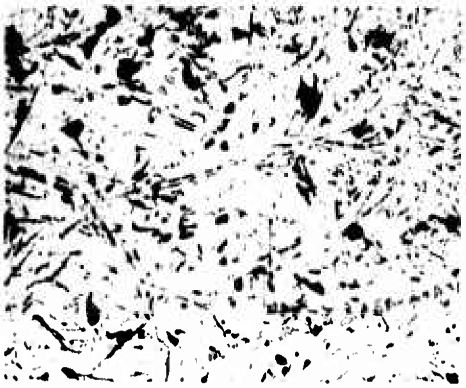
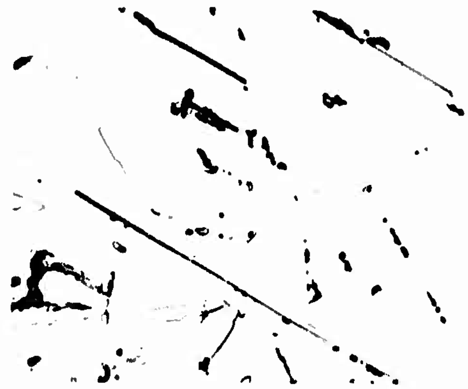


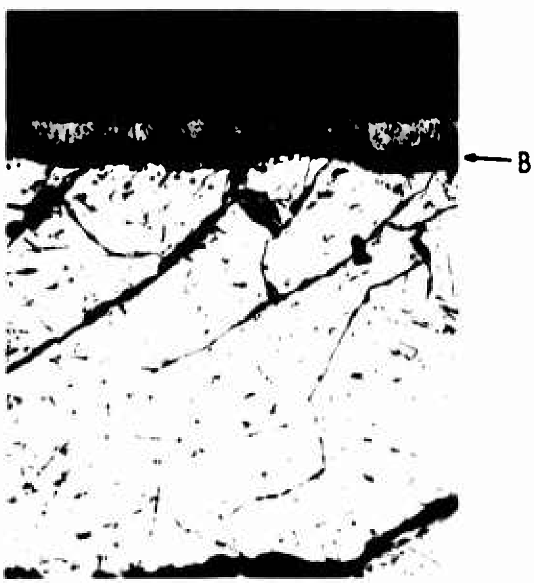
Figure 401. Elemental Electron Microprobe Scans for Cr, Co, Al, and Nb Across the Oxide and Affected Metal Zone



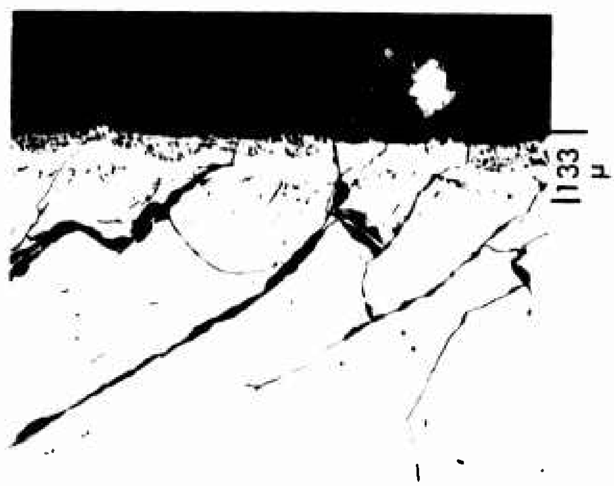
24510 (a) 75X
Polished and Etched



24510 (b) 500X
Polished and Etched

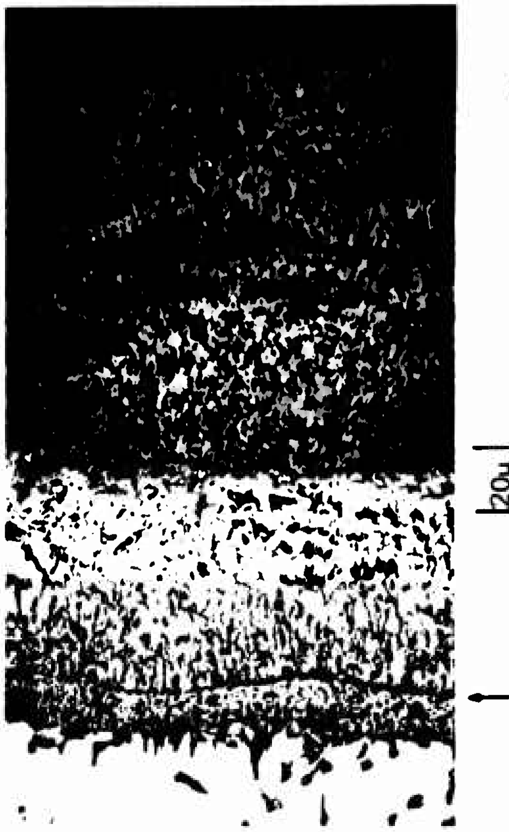


24709 (c) 75X
(etched)

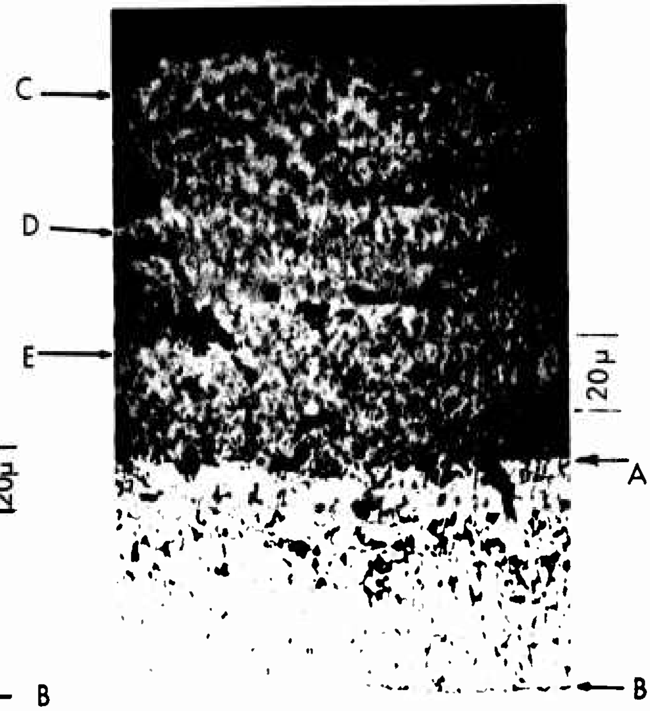


24709 (d) 75X
(unetched)

Figure 41. Microstructure, Oxide Scale, and Elemental Distribution of the Alloy Nb-10Cr-10Al-15Ni (DU-2) After Air Oxidation at 1200°C for 1360 min.

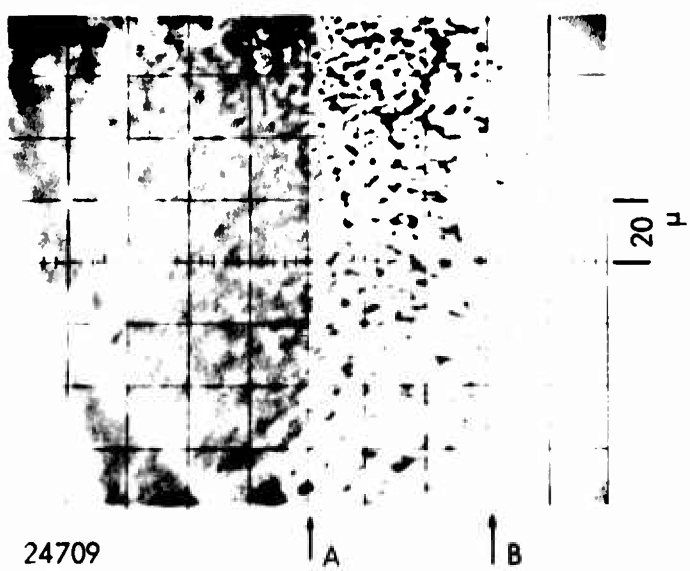


24709 (e)



24709 (f) 500X

Oxidation Zone (unetched)

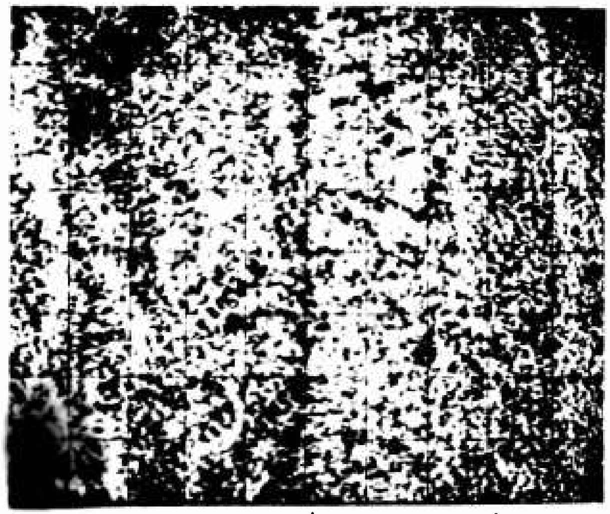


24709

(g)

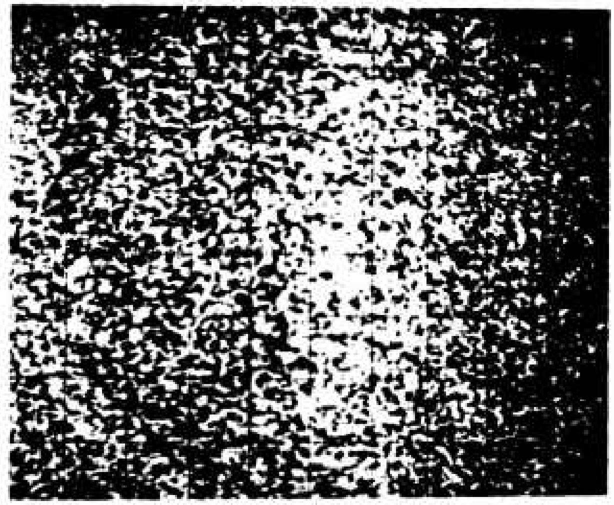
Backscatter Electron

Figure 41(e-g). Continued



24709 20μ A (h) B Cr

Chromium Distribution

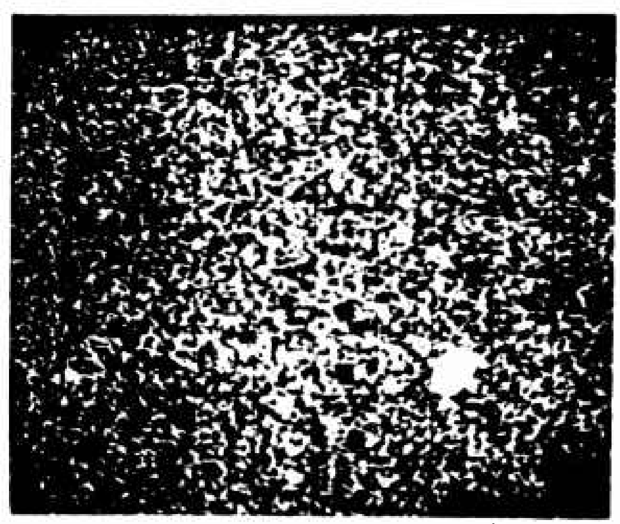


24709 (i) A B Al

Aluminum Distribution

24709 (j) A B Ni

Nickel Distribution

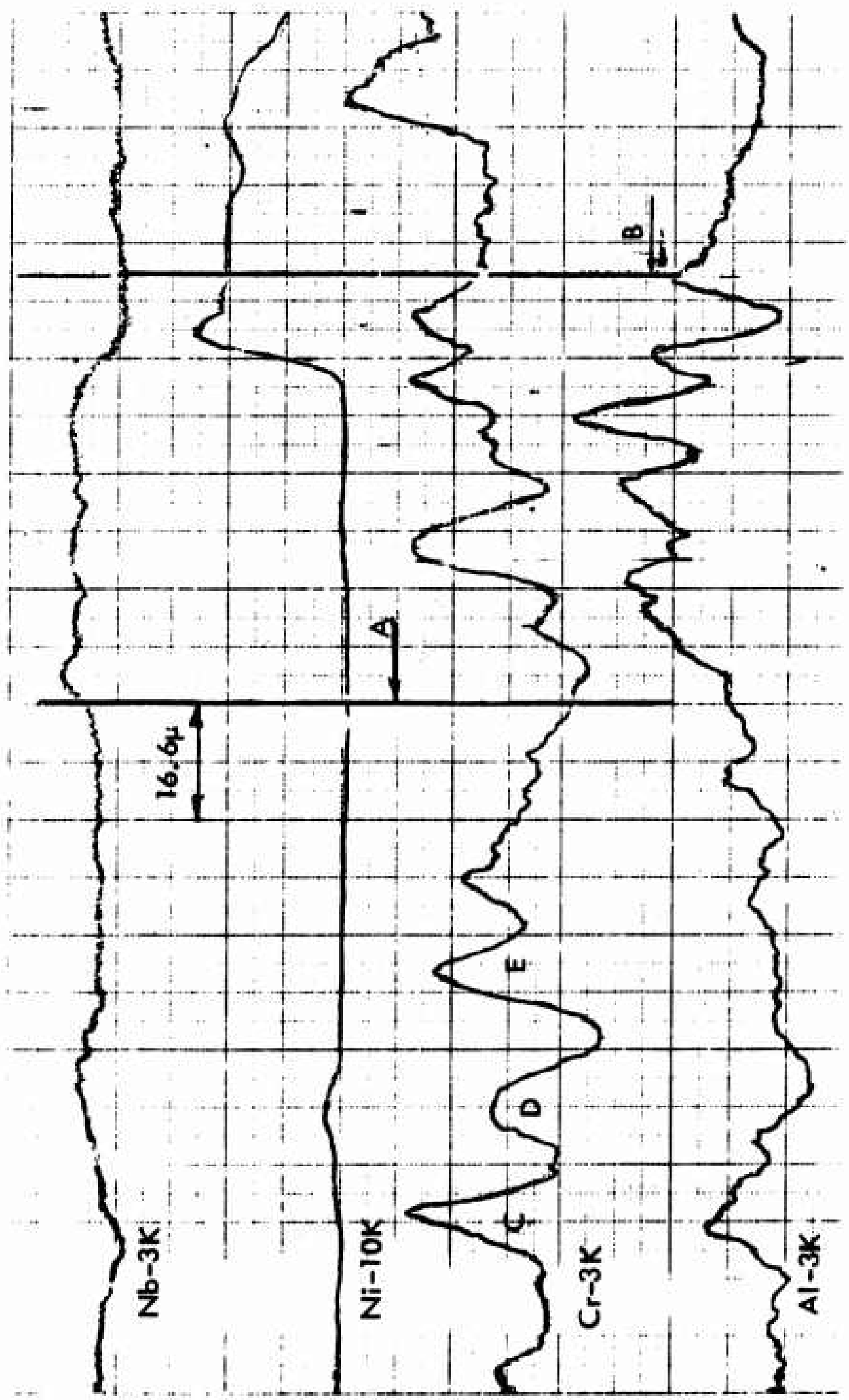


24709 (k) A B Nb

Niobium Distribution

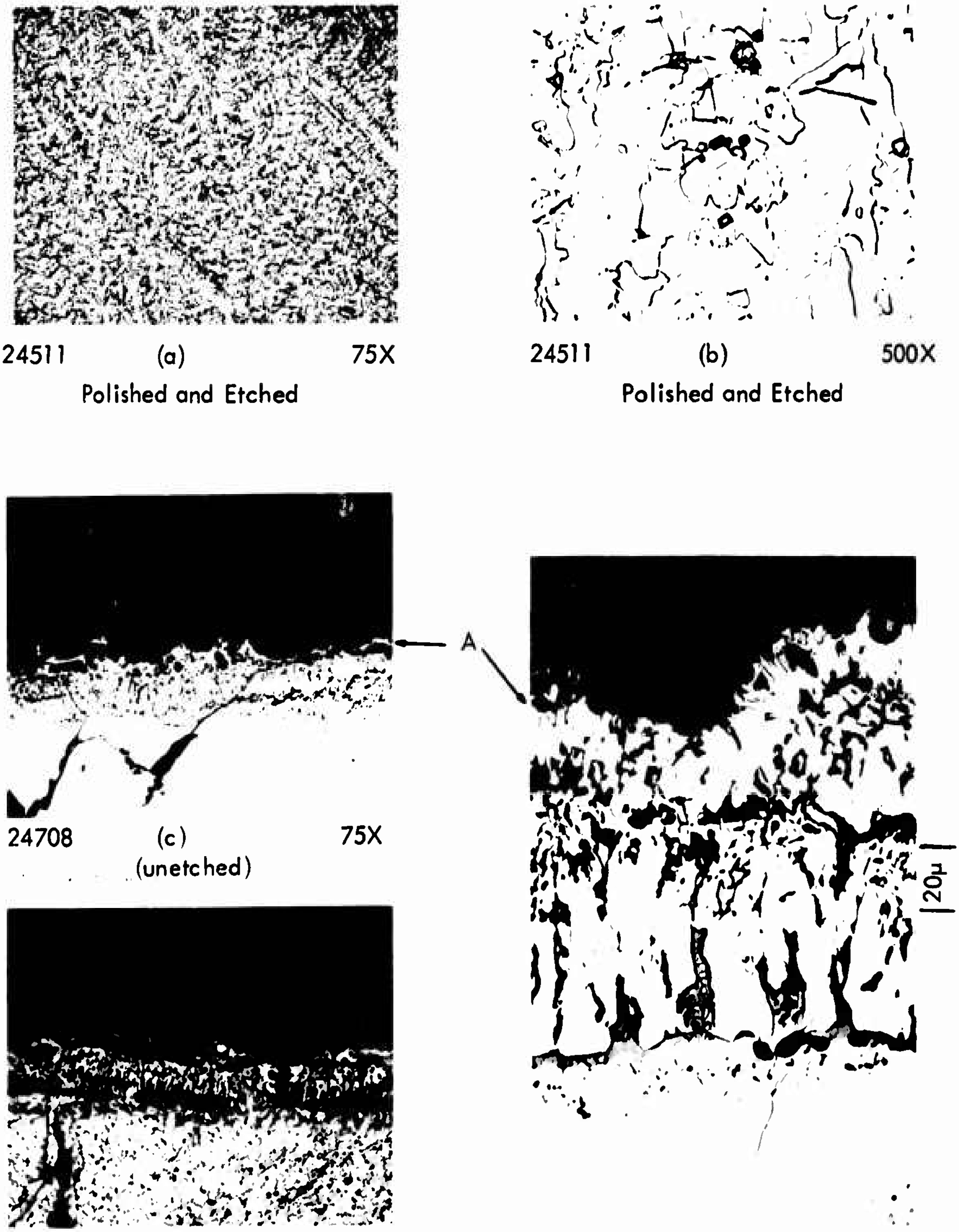
Figure 41(h-k). Microprobe Photographs Showing Elemental Distribution

24709
DU-2



(I)

Figure 41(I). Elemental Electron Microprobe Scans for Cr, Ni, Al, and Nb Across the Oxide and Affected Metal Zone



24511 (a) 75X
Polished and Etched

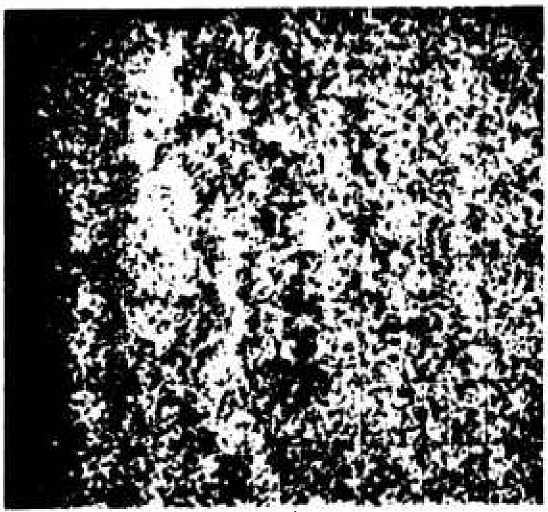
24511 (b) 500X
Polished and Etched

24708 (c) 75X
(unetched)

24708 (d) Etched 75X

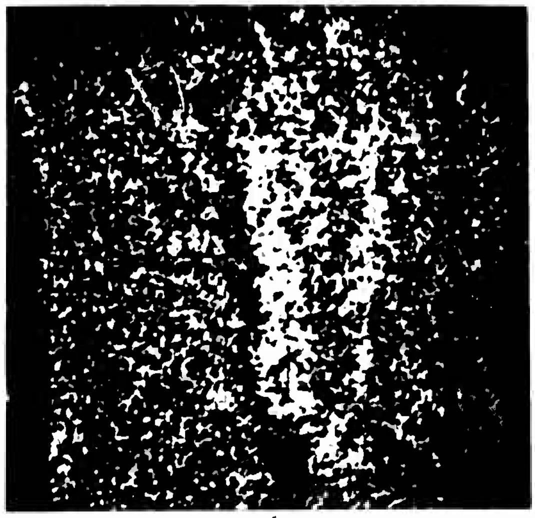
24708 (e) 500X

Figure 42. Microstructure, Oxide Scale, and Elemental Distribution of the Alloy Nb-9Cr-10Al-25Ni (DU-3) After Air Oxidation for 1647 minutes at 1200°C



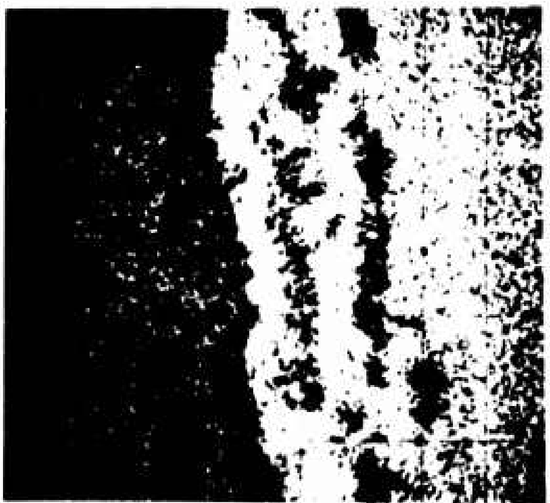
24708 (f) A Cr

Chromium Distribution



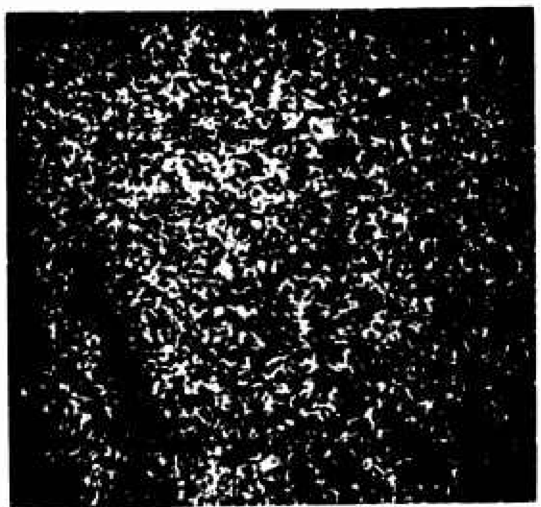
24708 (g) A Al

Aluminum Distribution



24708 (h) A Ni

Nickel Distribution

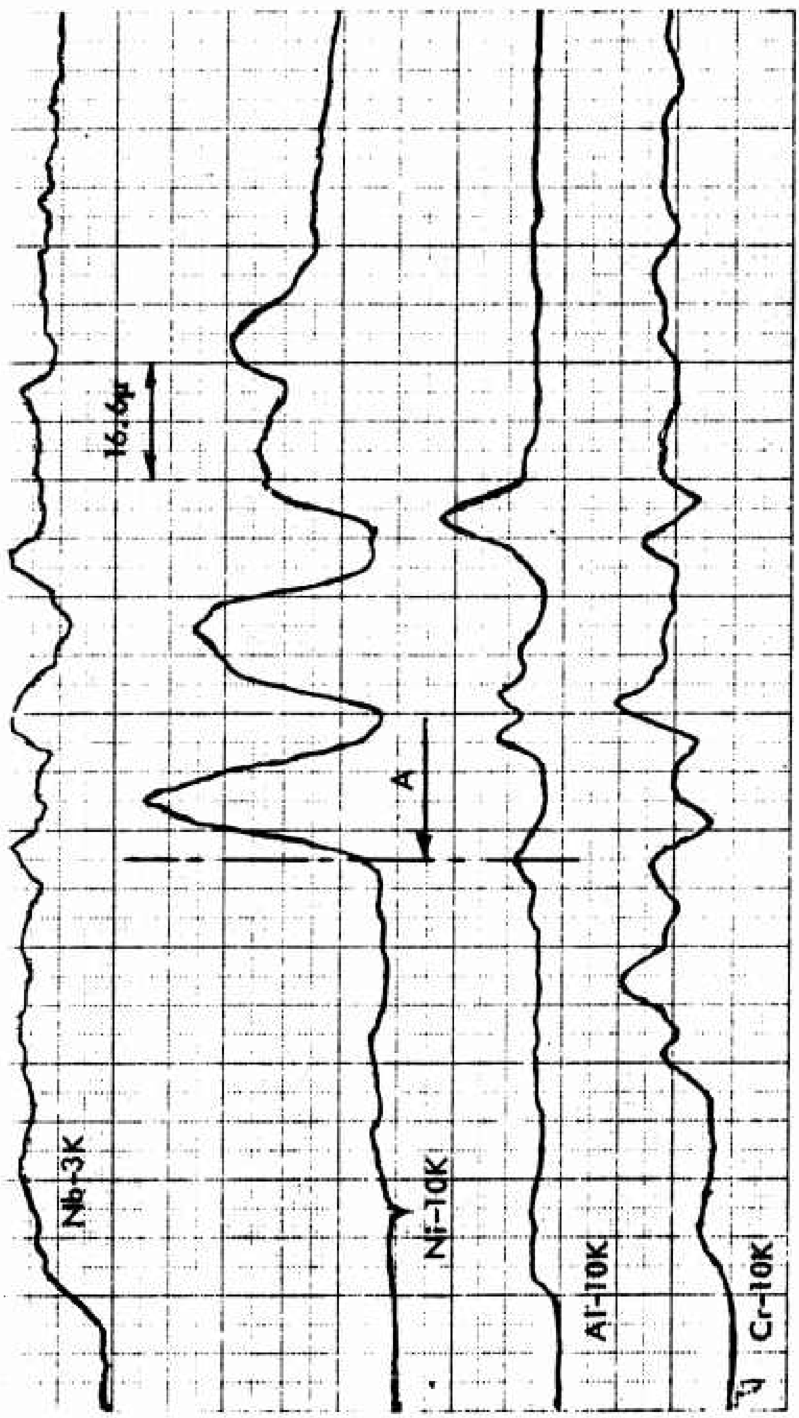


24708 (i) A Nb

Niobium Distribution

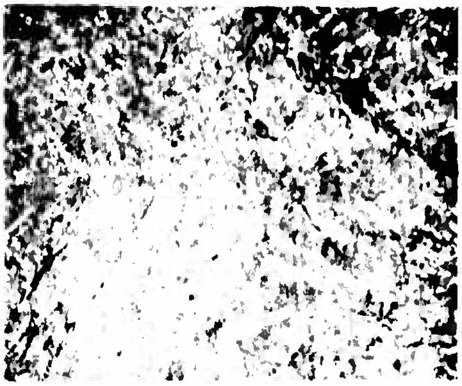
Figure 42(f-i). Microprobe Photographs Showing Elemental Distribution

24708
DU-3



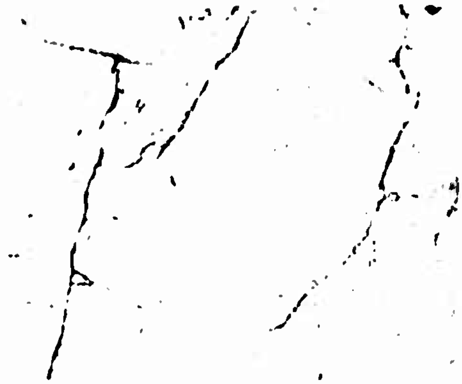
(j)

Figure 42(j).Elemental Electron Microprobe Scan for Cr, Ni, Al, and Nb
Across the Oxide and Affected Metal Zone



24512 (a) 75X

Polished and Etched



24512 (b) 500X

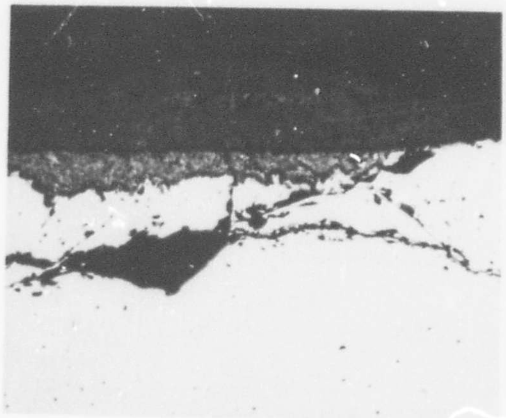
Polished and Etched

24707 (c) 500X

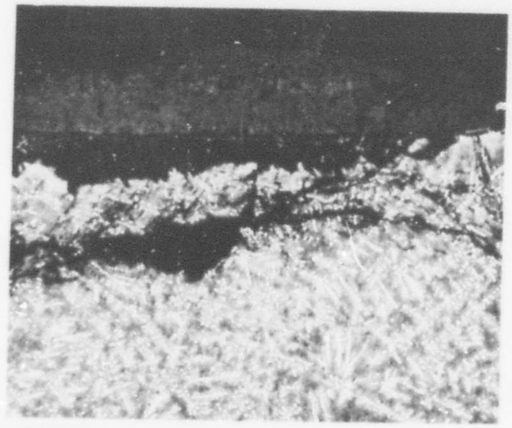
Etched

24707 (d) 500X

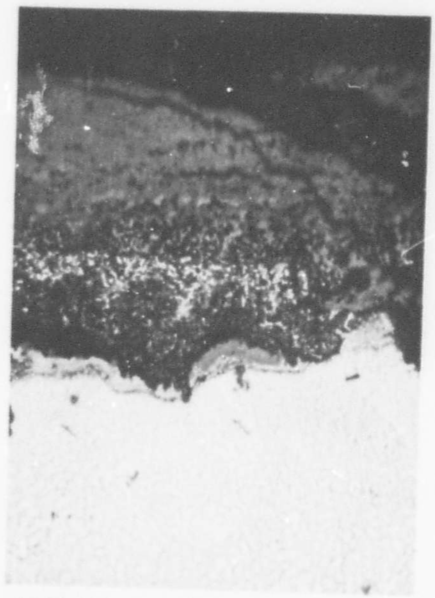
Figure 43. Microstructure, Oxide Scale, and Elemental Distribution of the Alloy Nb-10Fe-19Al (DU-4) After Aix Oxidation for 1371 minutes at 1200°C



24707 (e) 75X

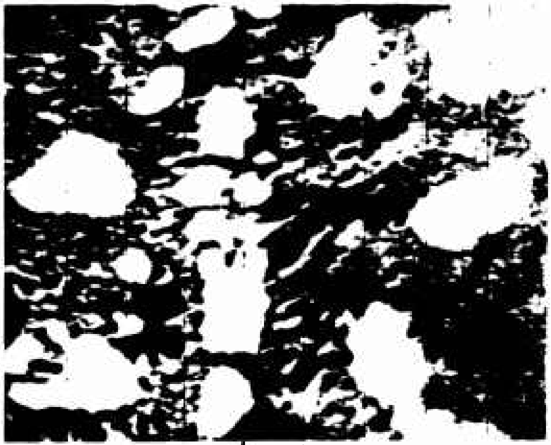


24707 (f)



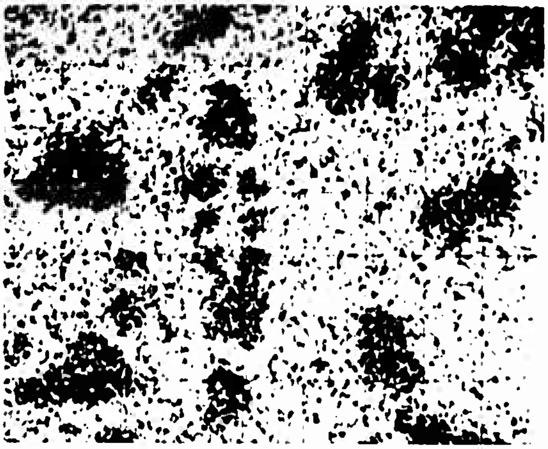
24707 (g) 500X

Figure 43(e-f)
Continued



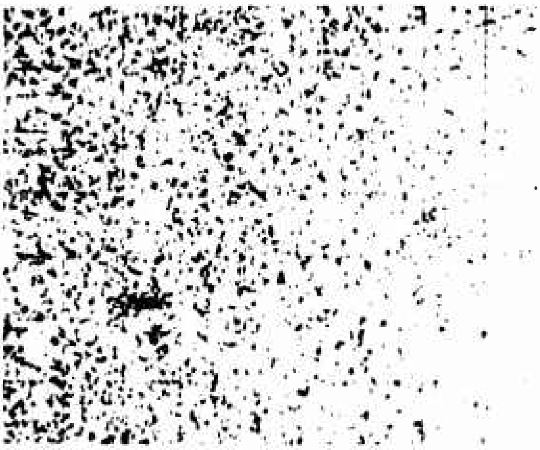
24512 (h) 20μ BSE

Backscattered Electron Pattern



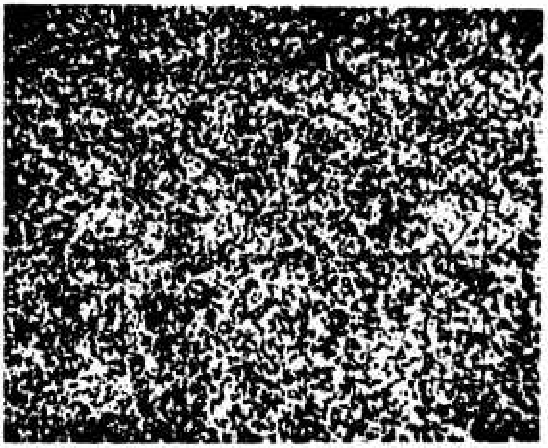
24512 (i) Fe

Iron Distribution



24512 (k) Al

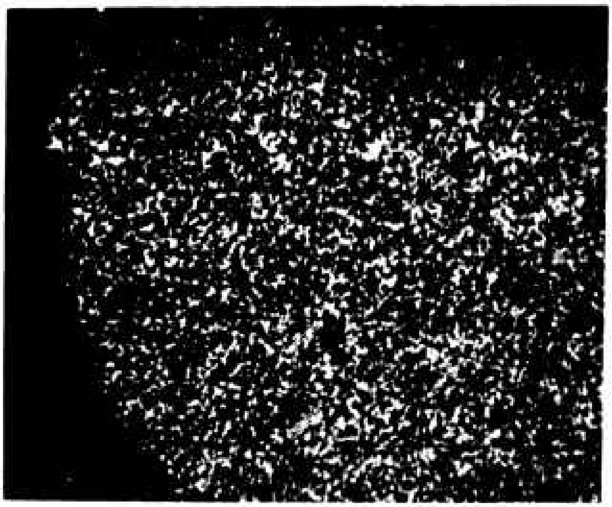
Aluminum Distribution



24512 (l) Nb

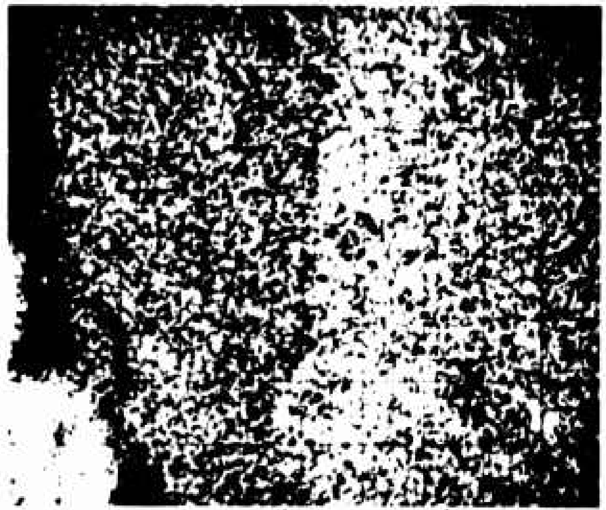
Niobium Distribution

Figure 43(h-l). Microprobe Photographs Showing Elemental Distribution in the As-melted Metal



24707 (m) Nb

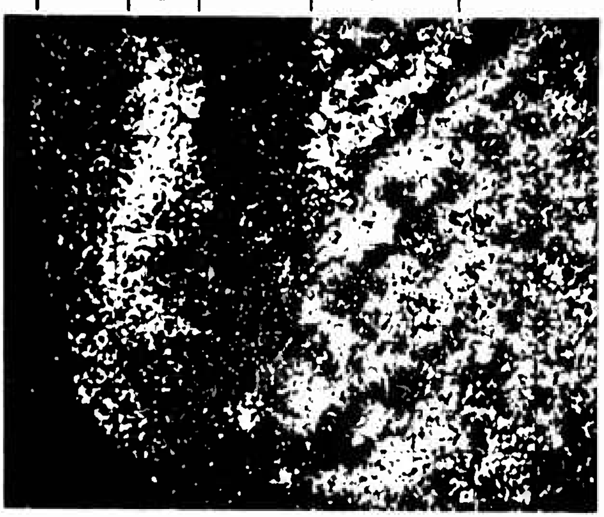
Niobium Distribution



24707 (h) | D | Al

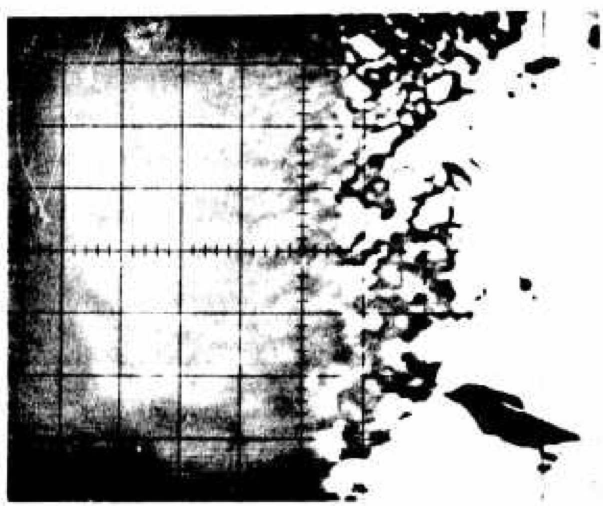
Aluminum Distribution

| A | B | C | D |



24707 (o) Fe

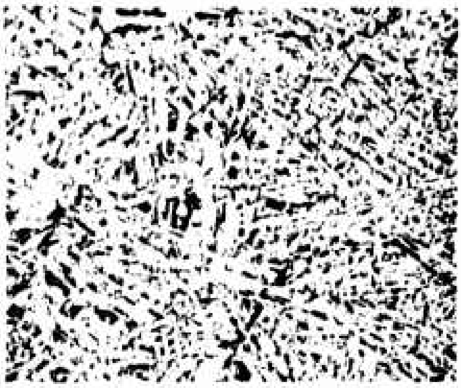
Iron Distribution



24707 (p)

Backscatter Electron

Figure 43(m-p). Microprobe Photographs Showing Elemental Distribution in the Oxide Scale



24513 (a) 75X

Polished and Etched

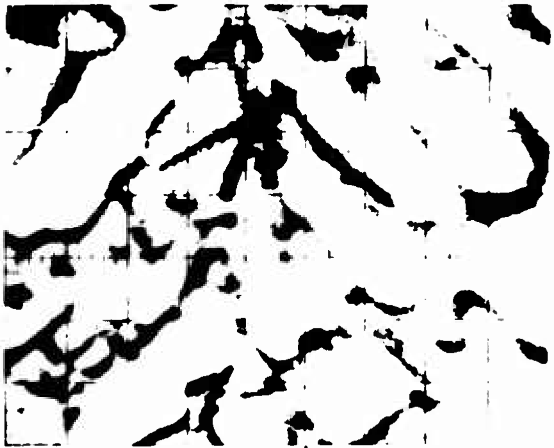
24513 (b) 500X

Polished and Etched

24706 (c) 500X

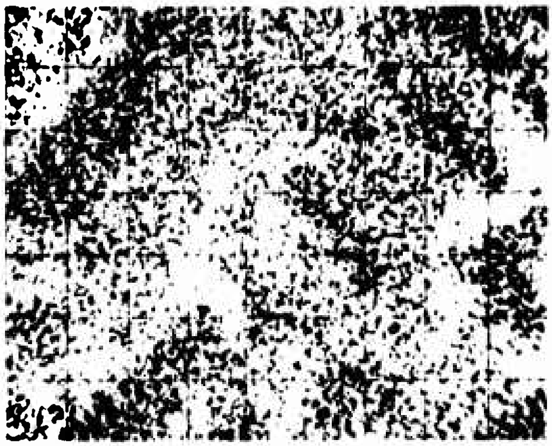
Oxide-Metal Interface
(Massive Oxide Spalled)

Figure 44. Microstructure, Oxide-Metal Interface, and Elemental Distribution of the Alloy Nb-20Fe-15Ti-0.5B After 1119 minutes at 1200°C

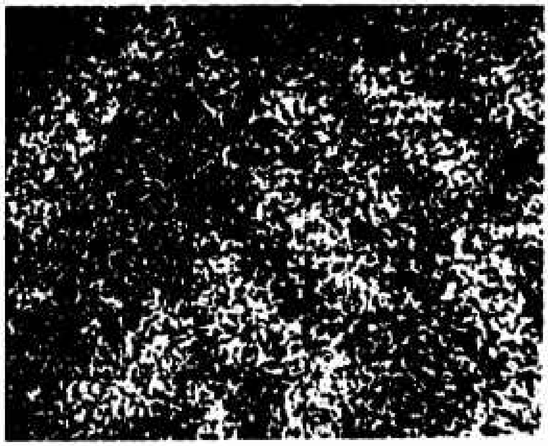


24513 (d) 10μ BSE
Backscattered Electron Pattern

24513 (e) Fe
Iron Distribution



24513 (f) Ti
Titanium Distribution



24513 (g) Nb
Niobium Distribution

Figure 44 (d-g). Microprobe Photographs Showing Elemental Distribution in the As-melted Metal

Table 8. DPH Hardness Values for As-cast Nb Based Oxidation Resistant Alloys

	Hardness	Load (kg)
DU-1	793	30
DU-2	855	10
DU-3	421	30
DU-4	833	10
UC-5	604	30

4.2 OXIDATION RESULTS

The oxidation rates of the five alloys at 1200°C are plotted in Figure 45 as weight loss/cm^2 vs time and as $(\text{weight loss})^2/cm^4$ vs time in Figure 46. From the slopes of the lines in Figure 46 the parabolic rate constants for the specific alloys listed in Table ? were calculated. For the alloys with initial and final rate constants, this indicates two distinct straight line regions. Only DU-1 shows a decrease in rate constant with time. The oxide phases identified by x-ray diffraction are listed in Table 10.

4.2.1 DU-1-Nb-19Cr-10Al-15Co

Figure 40(f) and (g) at 75X show three distinct zones in the alloy labeled I, II, and III excluding the oxide phase. Figure 40 (c and d) shows a 500X enlargement of the oxide metal interface. At the higher magnification, the boundary between zone I and II at C is not as evident. The electron beam microprobe results are presented in Figure 40 (h-k) as area photographs and in Figure 40(l) as elemental scans. The oxidation process is quite complicated. First of all, Cr_2O_3 is preferentially oxidized into the scale. Then a $CrNbO_4$ rutile phase is formed and then the $CoAl_2O_4$ spinel. As the Nb and Cr concentrations decrease, cobalt is concentrated at A (Figure 40j). Between the Cr rich outer scale structure and the cobalt rich interface, the oxide appears to be predominantly a Nb-Al compound. This zone appears to be preferentially attacked in the area just above zone I, A in Figure 40 (c and g). Based on Figure 40(g), the total affected metal zone appears to be about 170-180μ deep.

4.2.2 DU-2-Nb-10Cr-10A-15Ni

Figure 41(c-f) shows the etched and unetched oxide metal interfaces. The phase or zone adjacent to the oxide in Figure 41(d) is not continuous. Figure 40(c) shows the structure at B to be easily etched. Figure 40(h) and the Ni scan on Figure 40(l) indicate that little or no nickel is incorporated into the oxide scale. In fact, the nickel concentration

Table 9. Parabolic Rate Constants for the Niobium Based Alloys

	Parabolic Rate Constant ($mg^2/cm^4/min$)	
	Initial	Final
DU-1	.045	.037
DU-2	.115	.543
DU-3	.300	1.2
DU-4	.323	1.32
UC-5	25.283	--

Table 10. Results of Debye X-ray Diffraction Analysis on the Oxides Formed at 1200°C on the As-melted Niobium Based Alloys

Alloy	Phases Identified	ASTM Card No.
DU-4 Nb-Fe-Al	$AlNbO_4$	14 - 494
UC-5 Nb-Fe-Ti-B	Rutile Structure TiO_2	4 - 0550
	Matches $CrNbO_4$ (but no Cr in alloy)	20 - 311
	TiO_2	21 - 1276
	Fe-Nb-Ti-O	16 - 934
	Nb_2O_5 & Ti-Nb-O (Match some extra lines)	
DU-3 Nb-Cr-Al-Ni	Rutile Structure	
	($CrNbO_4$)	20 - 311
	$AlNbO_4$	14 - 494
	Very weak possible "Nb_2O_5"	
DU-2	Same as DU-3 except for small parameter change	
DU-1	Rutile Structure	
	($Cr\ NbO_4$)	20 - 311
	$CoAl_2O_4$	10 - 458
	($a_o \sim 8.25$)	

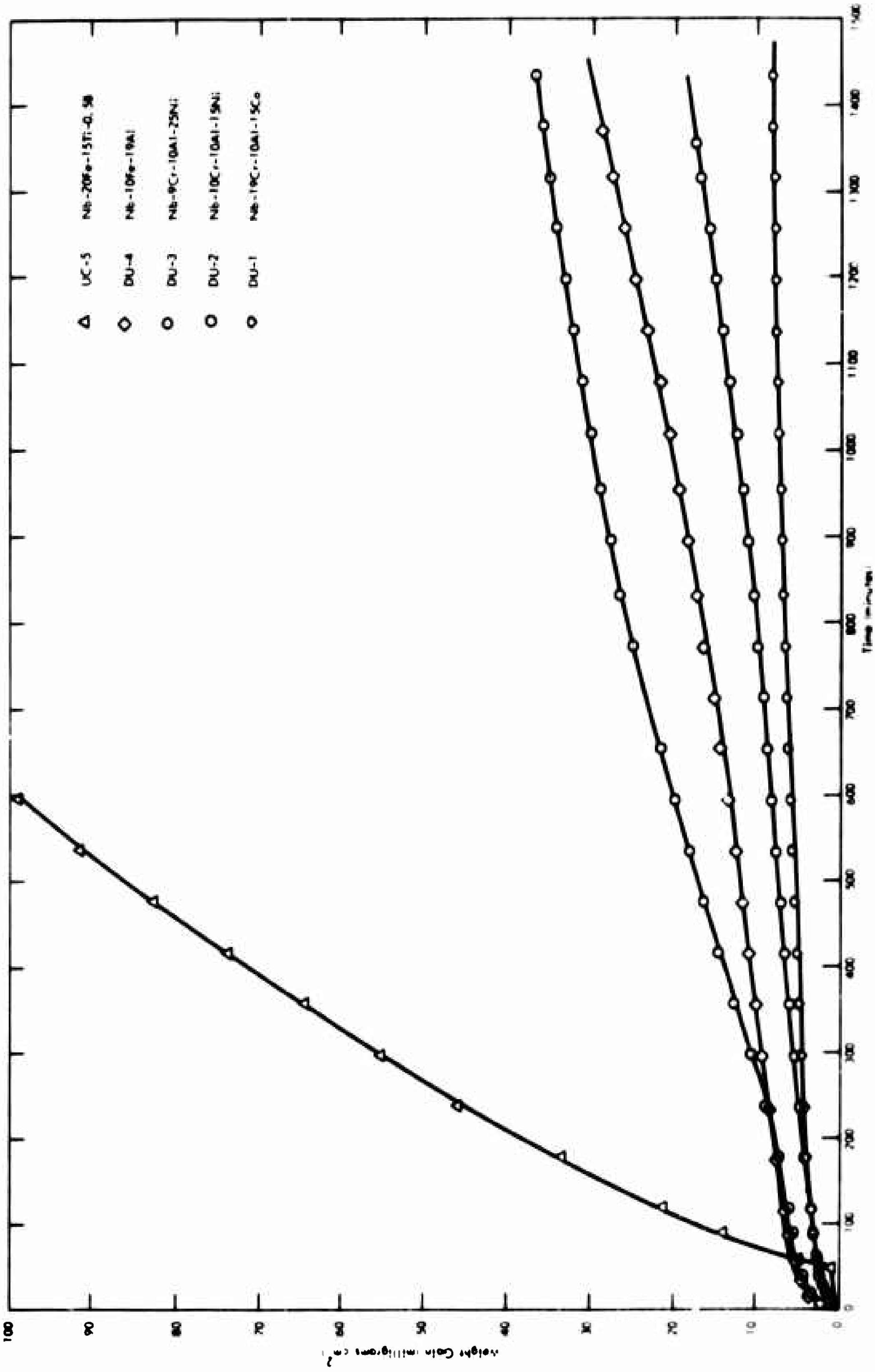


Figure 45. Oxidation Kinetics of Some Experimental Niobium Alloys in Air at 1200°C

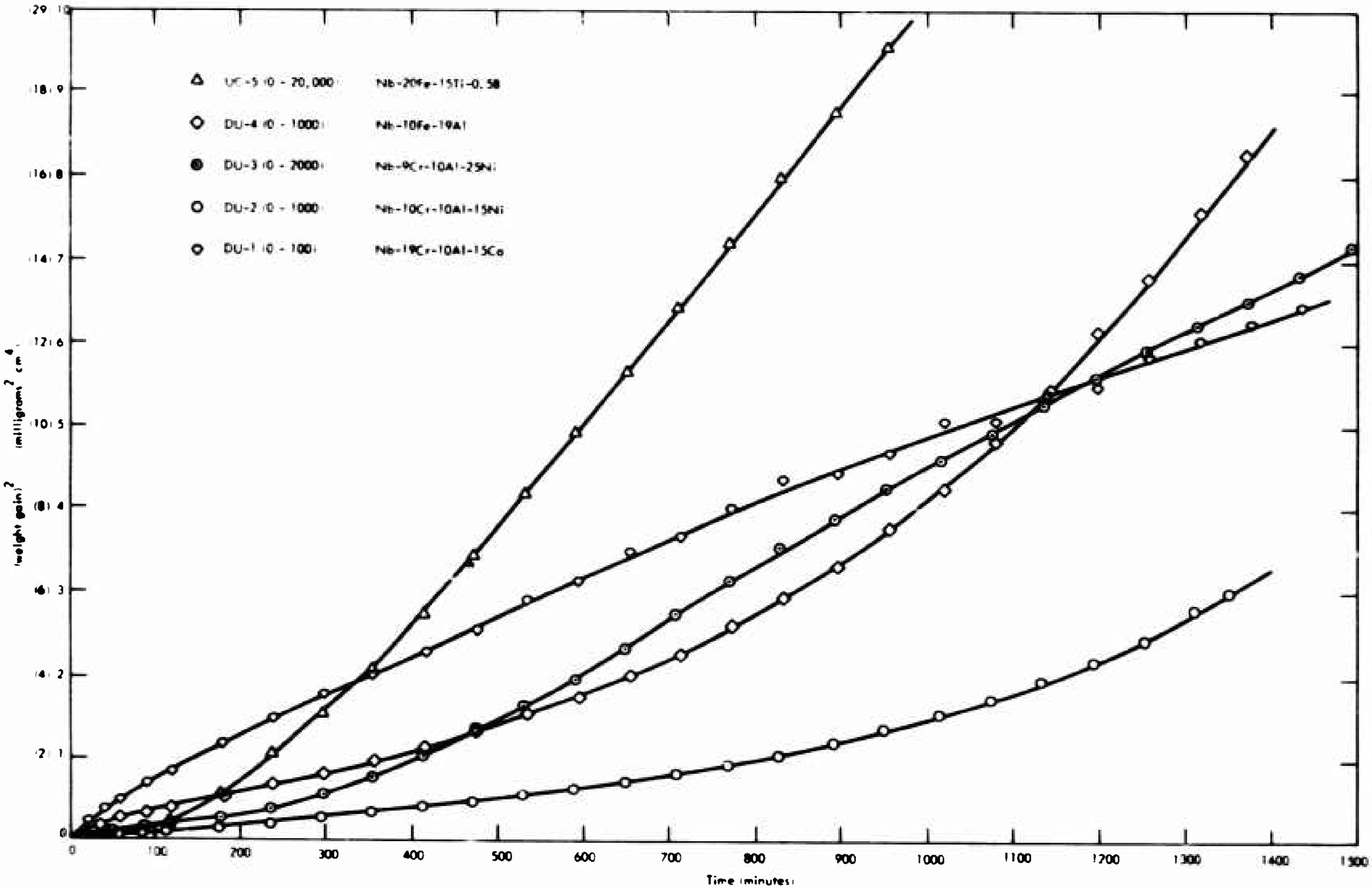


Figure 46. Plot of $(\Delta M/A)^2$ vs Time for Experimental Niobium Alloys Oxidized in Air at 1200°C

appears to be built up just ahead of B. At the point where the nickel concentration increases, the Nb concentration decreases, and the aluminum concentration also reaches a minimum. The x-ray diffraction results also indicate no nickel containing compounds in the oxide. The internal oxidation zone A-B contains a large percentage of the aluminum. Apparently, the aluminum is internally oxidized before incorporation into the scale. In this zone high Al peaks are associated with low Cr peaks, and the high Cr peaks are associated with the low Al peaks. The zone below B, which appears on Figure 40(e), is apparently depleted in chromium concentration because immediately below this a large Cr peak is evident. In the oxide, the chromium peaks can be closely associated with the structure in the oxide at C, D, and E as shown in Figure 41(f and l). Again, the rutile type $BNbO_4$ structure is predominant in the oxide. The affected metal zone extends about 70 μ below the oxide-metal interface.

4.2.3 DU-3;Nb-9Cr-10Al-25Ni

The general oxidation behavior of this alloy is similar to that of alloy DU-2 in that no Ni is formed in the scale but is rejected back into the first affected zone below A. The scale forms the rutile oxides as shown in DU-2. The additional nickel appears to cause a larger affected zone and a thicker oxide scale as is shown by the larger weight gain/cm^2 with time. In addition, the largest chromium concentration in the oxide now appears to be below the surface; whereas for DU-2, the Cr seemed to be concentrated in three specific layers.

4.2.4 DU-4;Nb-10Fe-19Al

DU-4 exhibited better oxidation resistance than did DU-3. However, the oxidation behavior was not uniform over the surface of the sample. Figure 43(c) indicates the selective oxidation of the Nb-Al rich phase depleted in iron (Figure 43i). Compare the oxidation products shown in Figure 43(g) with those shown in Figure 43(c). Where

the iron depleted phase is finely distributed, the oxidation front proceeds with the production of an adherent oxide scale. The metallic phase in the oxide scale shown in Figure 43(g) is iron. Figure 43(o) shows the iron distribution.

Microprobe examination of the oxide metal interface of alloy DU-4 (Figure 43 m-p) shows that the outer oxide consists of a niobium alumina-oxygen region (A), a region in which iron is concentrated along with quantities of NbAl and Fe(B), then a region delete of iron on the oxide side of the oxide-metal interface (C). An aluminum enriched zone appears in the metallic layer, probably the result of the internal oxidation of aluminum by the alloy.

4.2.5 UC-5;Nb-20Fe-15Ti-0.5B

UC-5 oxidized quite rapidly, and the scale spalled. The oxide contained a rutile structure which matched the card for $CrNbO_4$ even though there was no chromium in the alloy. This must be a Ti NbO_4 compound. However, several other oxides were also found in the scale. This is typical of the nonprotective oxides formed on these alloys. Unless the rutile-hematite structure is present in the scale, the oxidation behavior of the alloys was extremely poor.

5.0 OXIDATION BEHAVIOR OF Nb-Ti-Cr-Al ALLOYS

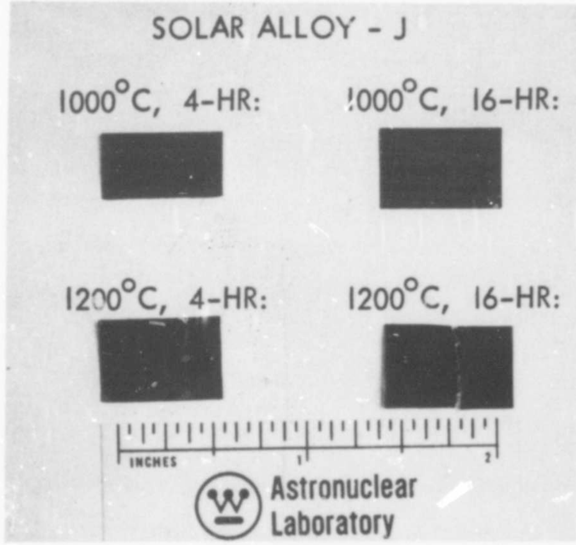
Samples of Solar's[28] J-Alloy (Nb-40Ti-9Cr-4Al) and B-IV Alloy (Nb-42Ti-4Cr-4Al-IV) were acquired from the Solar Division of International Harvester. These alloys have been oxidized in air, kinetic data obtained, and x-ray analyses have been made of the scales formed. Also, microprobe traces across the samples were made to determine the movement of the elements during oxidation in air at 1000°C and 1200°C.

The samples in the form of 10 mil sheets were first oxidized in air in the Stanton Thermo-balance. Figure 47 shows the external appearance of the alloys after oxidation. The Solar Alloy-J exposed for 16 hours at 1200°C was purposely cracked after exposure. In the thin section, all of the 1200°C alloys were brittle, even after 4-hour exposure.

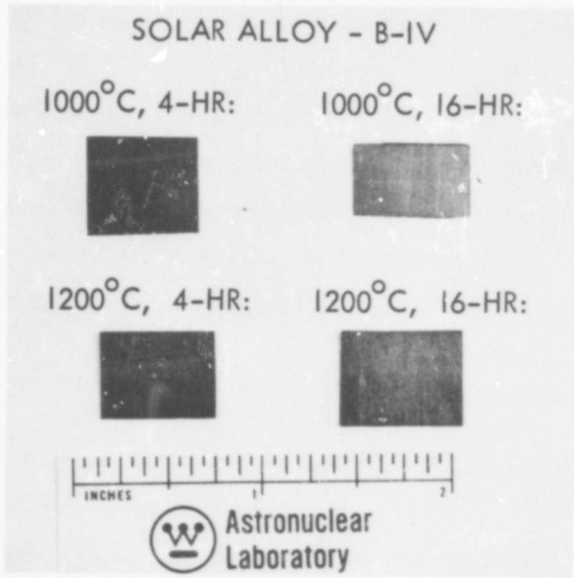
The oxidation data are plotted in Figure 48 as $\Delta M/A$ (milligrams/cm^2) and in Figure 49 as $\Delta M^2/A^2$ (milligrams^2/cm^4), the latter to indicate deviations from parabolic oxidation behavior. Figures 50 through 57 show the etched and unetched microstructures and the oxidation products formed as well as microprobe profiles across the oxide-matrix-oxide sample. The microprobe traces were made using a scanning electron beam rather than by moving the sample under a stationary electron beam. The slope in some of the profiles, i.e., Figure 50 (Ti-30K) is the result of a change in the angle of the emitted x-rays and the detector and is not composition dependent.

5.1 J-ALLOY; Nb-40Ti-9Cr-4Al

Figures 50-53 show the effects of exposures of 4 and 16 hours at 1000°C and 4 and 16 hours at 1200°C for the Solar-J Alloy in air. Figure 50, 4 hours at 1000°C, shows no depleted regions; the alloy remaining quite homogeneous. Figure 51, 16 hours at 1000°C, begins to show chromium in the outer scale (Figure 51d). In Figure 51(e), this chrome concentration in



(a)



(b)

Figure 47. Post-oxidation Appearance of the Solar Alloys Oxidized in Air at the Conditions Indicated

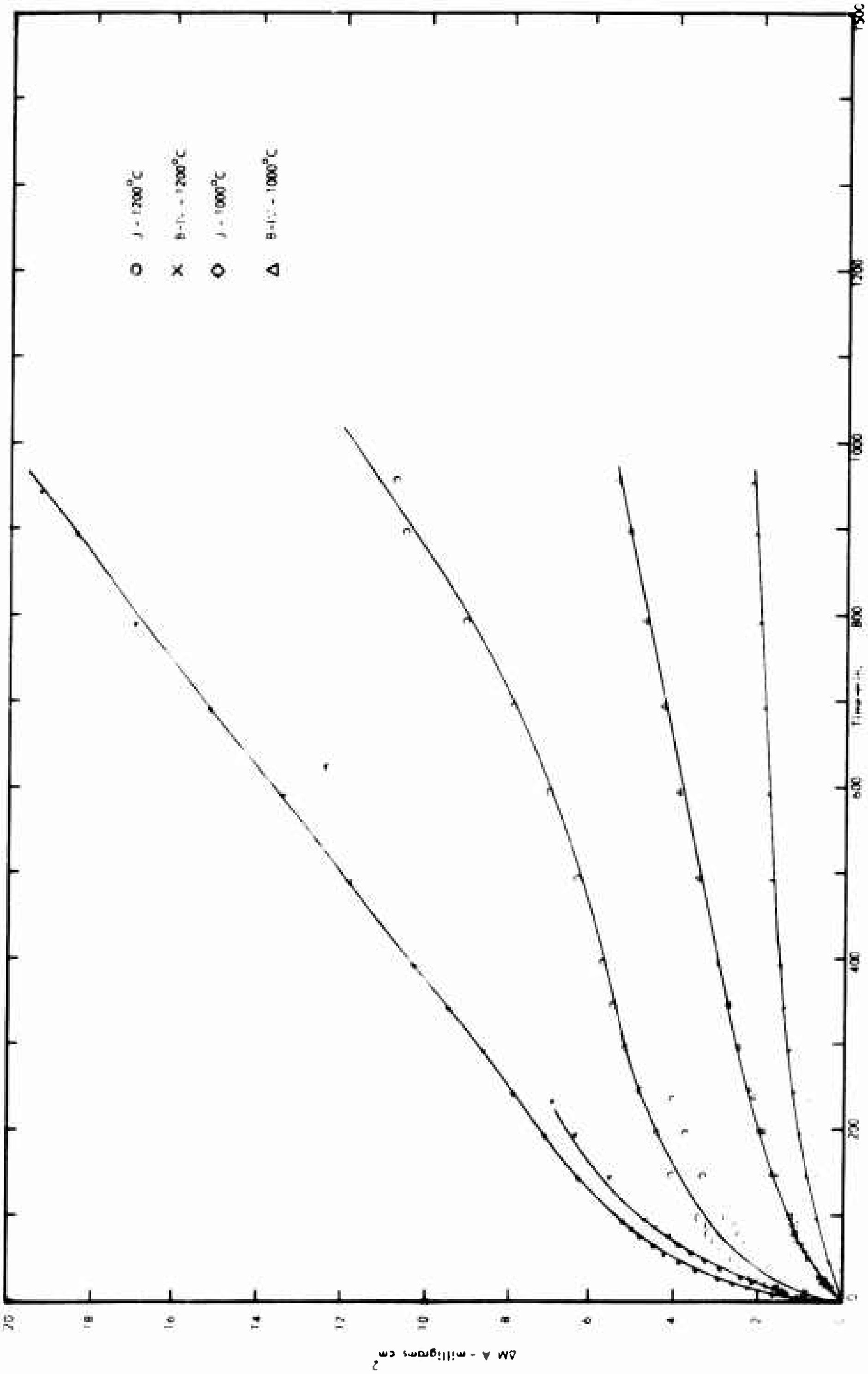


Figure 48. The Oxidation Rate of the Solar J and B-IV Alloys in Air as a Function of Time and Temperature

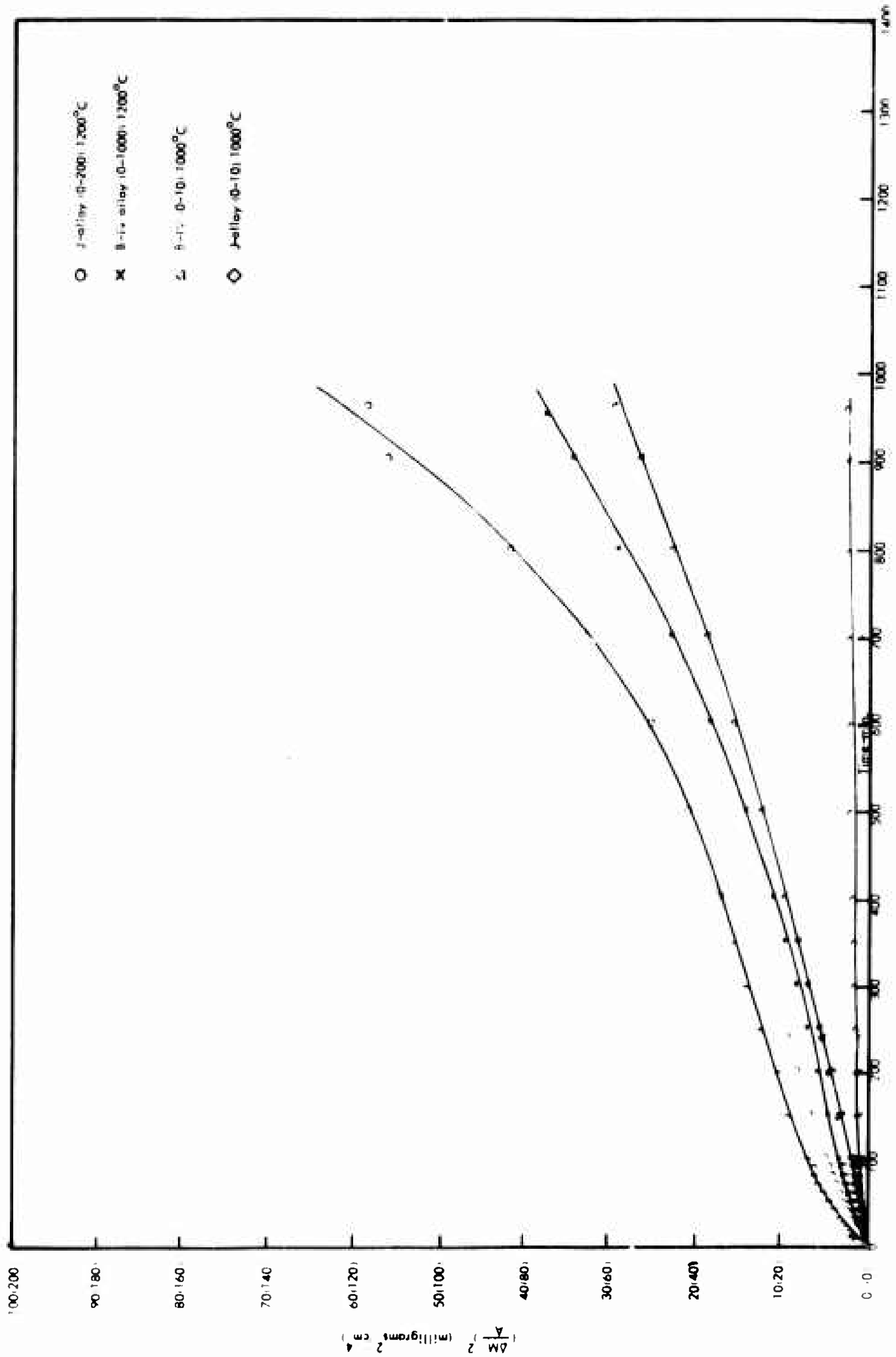
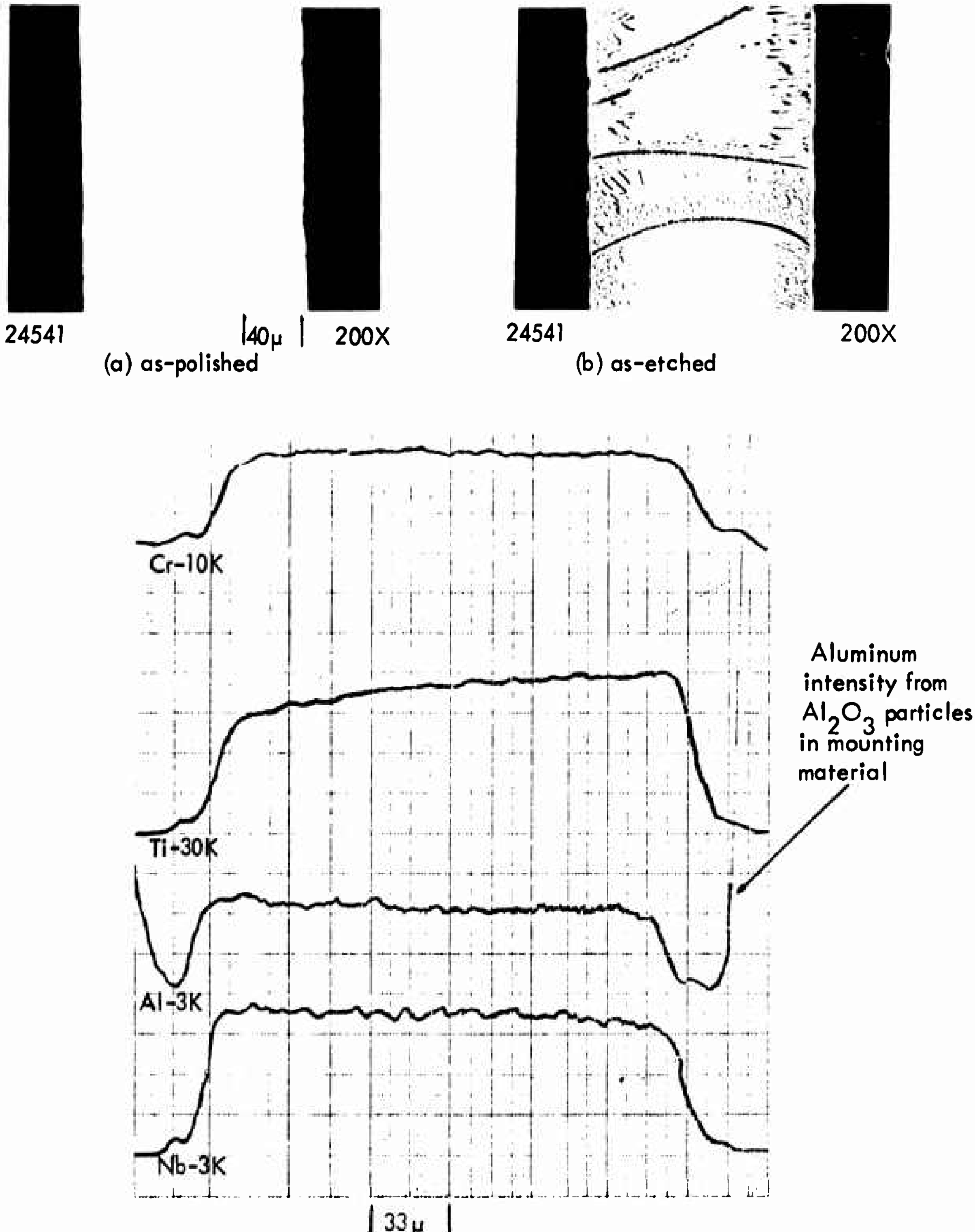


Figure 49. The Plot of $(\Delta M/A)^2$ vs Time from Which the Parabolic Rate Constant was Calculated.
Departure from straight line behavior denotes non-parabolic oxidation kinetics

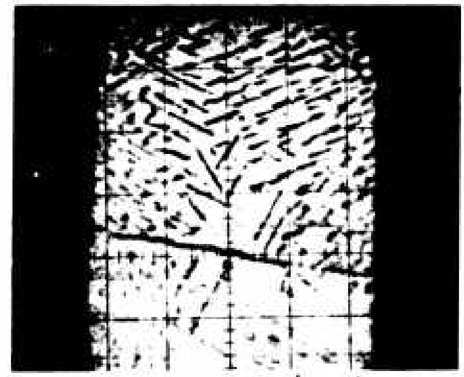


(c) Microprobe traces

Figure 50. Microstructure, Oxide Scale, and Elemental Distribution for the Solar J alloy after a 4 hour Air Oxidation Exposure at 1000°C

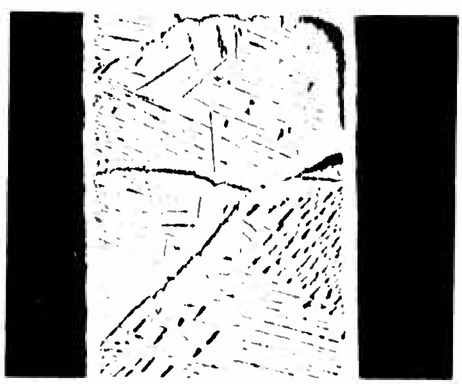
24540 | 50μ | 200X

(a) As-polished



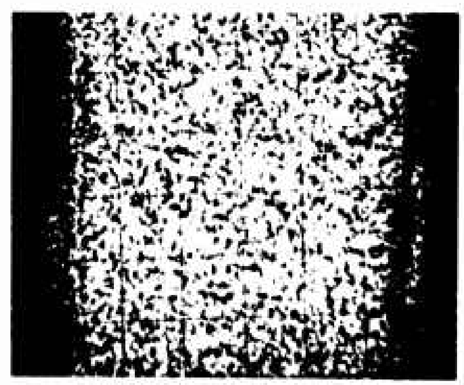
| 40μ | 200X

(c) Backscatter electron pattern



24540 200X

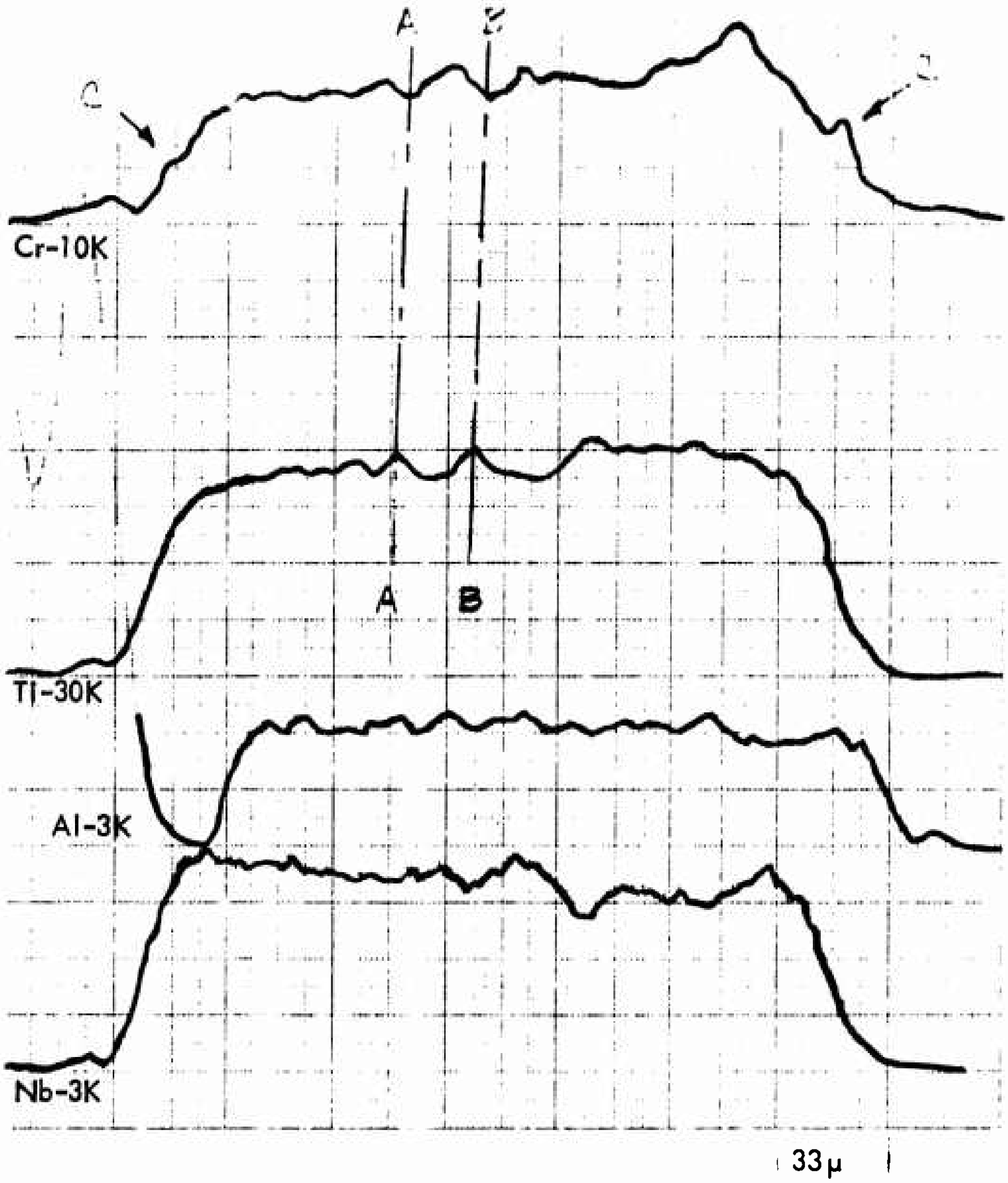
(b) As-etched



200X

(d) Chromium Distribution

Figure 51. Microstructure, Oxide Scale, and Elemental Distribution for the Solar-J Alloy after a 16 hour Air Oxidation Exposure at 1000°C



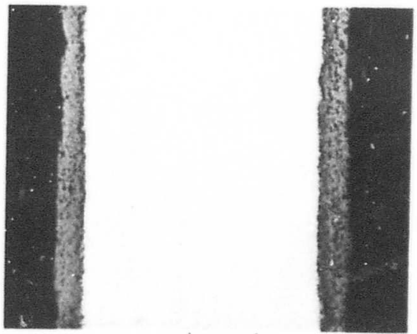
(e)

Figure 51e. Elemental Electron Microprobe Scans of Cr, Ti, Al, and Nb

the scale is denoted by the peaks at C on the chromium trace. By comparing the microprobe traces for chromium and titanium it is evident that the chromium rich areas are areas also depleted in titanium (see lines A-A and B-B in Figure 51e). The areas attacked by the etching appear to be rich in titanium and depleted in chromium. This fact will become evident as the time and temperature of the oxidation exposure is increased.

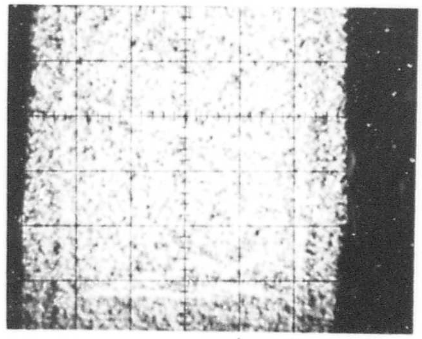
Figure 52 shows the effect of 4 hours exposure at 1200°C. Here an oxide scale is formed as well as a depleted layer between the oxide and matrix. Figure 52(c) shows the chromium segregation in the outer edge of the oxide scale, as was also seen in Figure 51. Figure 52(f) also shows an aluminum concentration in the outer most part of the oxide scale. This is also shown on Figure 52g, identified by B and D. These two conditions indicate that both chromium and aluminum are preferentially oxidized until their concentration is depleted from the subsurface layer. The rate of chromium and aluminum consumption is then dependent on their rate of diffusion from the matrix through the depleted layer and through the oxide layer. As noted previously in Figure 51e line A-A in Figure 52g denotes the mutual separation of the titanium and chromium in the metal phase. This is also shown by comparing Figures 52c and 52d. The area denoted by C-C indicates that Nb and Al concentrations vary together, indicating a mutual affinity of these elements for each other in the matrix.

Figure 53 supports the conclusions made above and also indicates that titanium and chromium are present together in the oxide, although as previously indicated, these elements tend to segregate in the matrix. Lines A-A and B-B in Figure 53g show that the titanium rich areas are depleted in niobium and aluminum, also. This sample does not show the same relationship between chromium and aluminum as did the three previous samples, however, note that chromium moved almost completely out of the matrix (see D in Figure 53g).



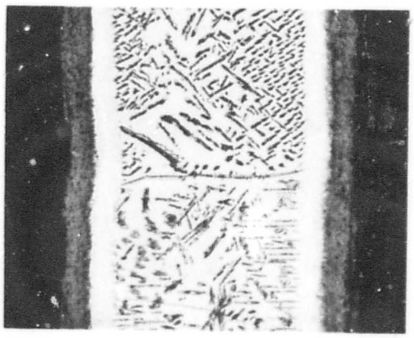
24539 |50 μ| 200X

(a) As-polished



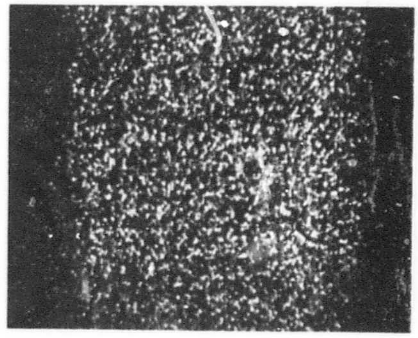
|40μ|

(d) Titanium Distribution

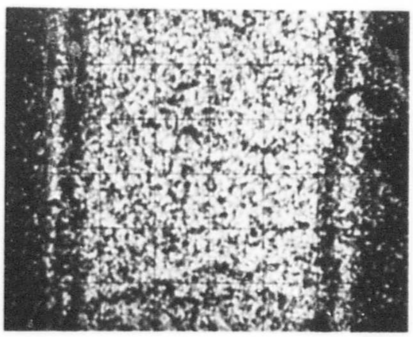


24539

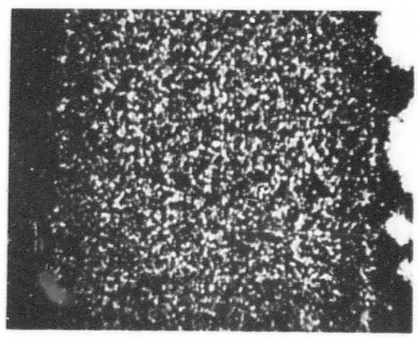
(b) As-etched



(e) Niobium Distribution

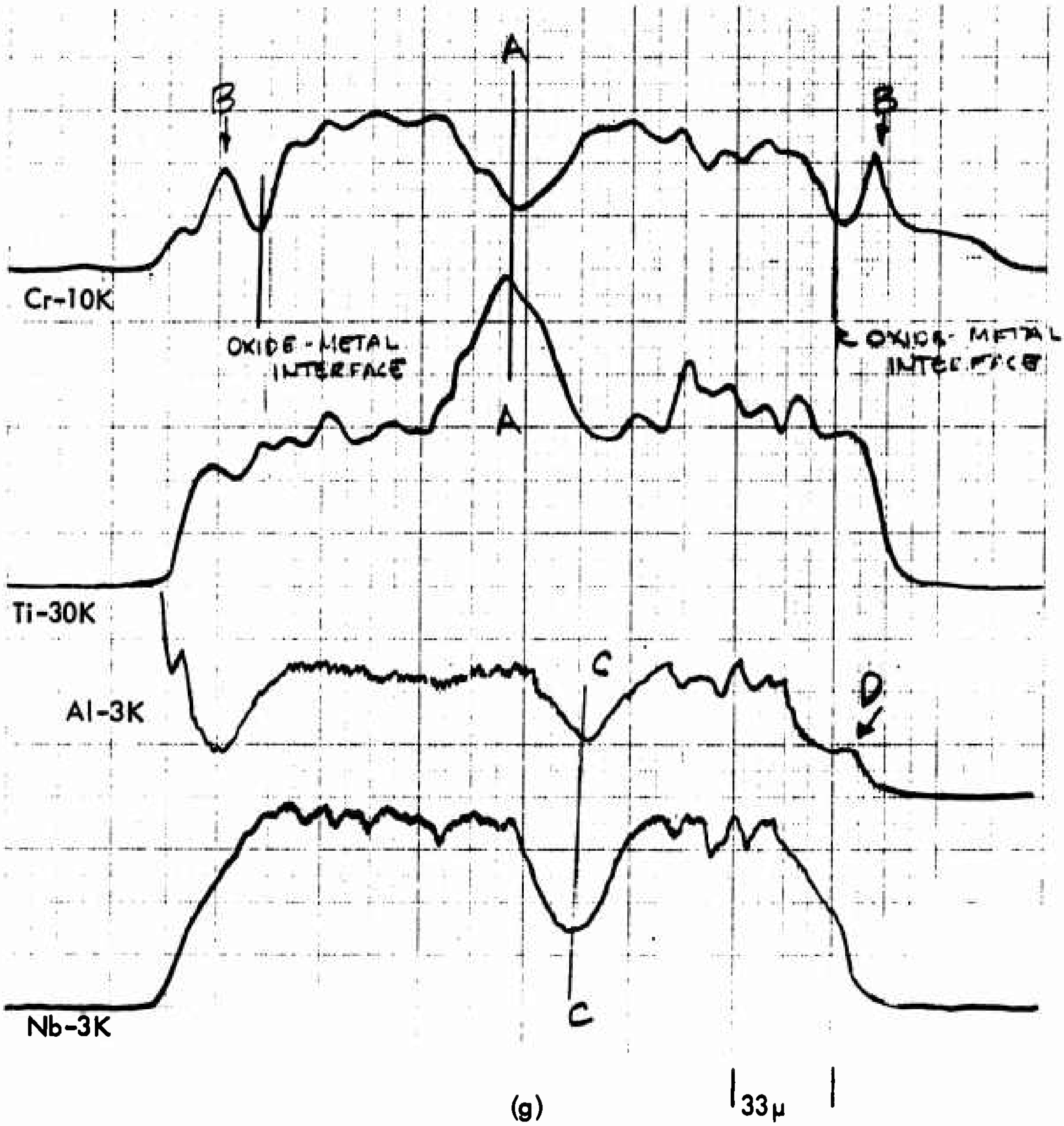


(c) Chromium Distribution



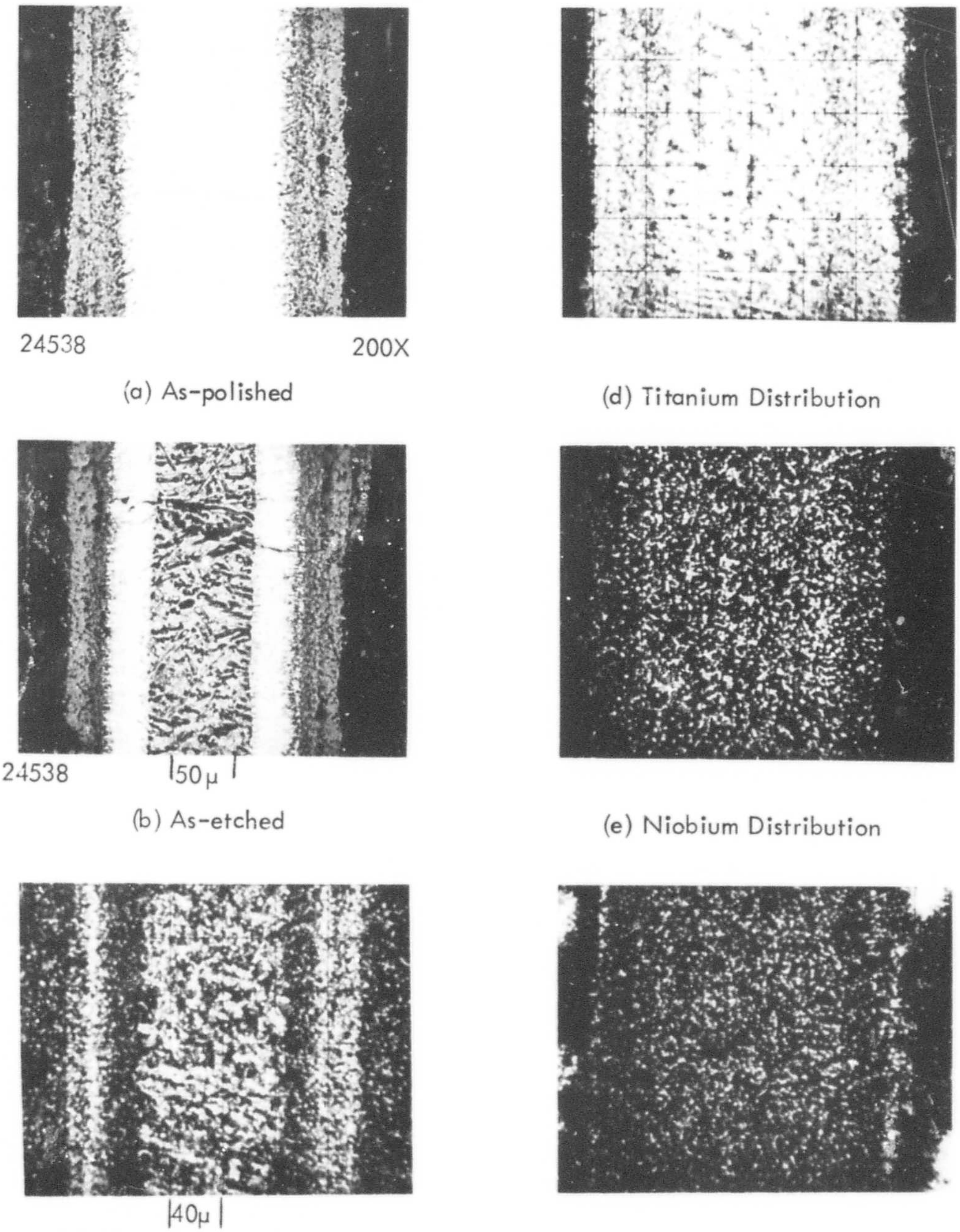
(f) Aluminum Distribution

Figure 52. Microstructure, Oxide Scale, and Elemental Distribution for the Solar-J Alloy after a 4 hour Air Oxidation Exposure at 1200°C



(g)

Figure 52g. Elemental Electron Microprobe Scans of Cr, Ti, Al, and Nb.



(a) As-polished

(b) As-etched

(c) Chromium Distribution

(d) Titanium Distribution

(e) Niobium Distribution

(f) Aluminum Distribution

Figure 53. Microstructure, Oxide Scale, and Elemental Distribution for the Solar-J Alloy after a 16 hour Air Oxidation Exposure at 1200°C

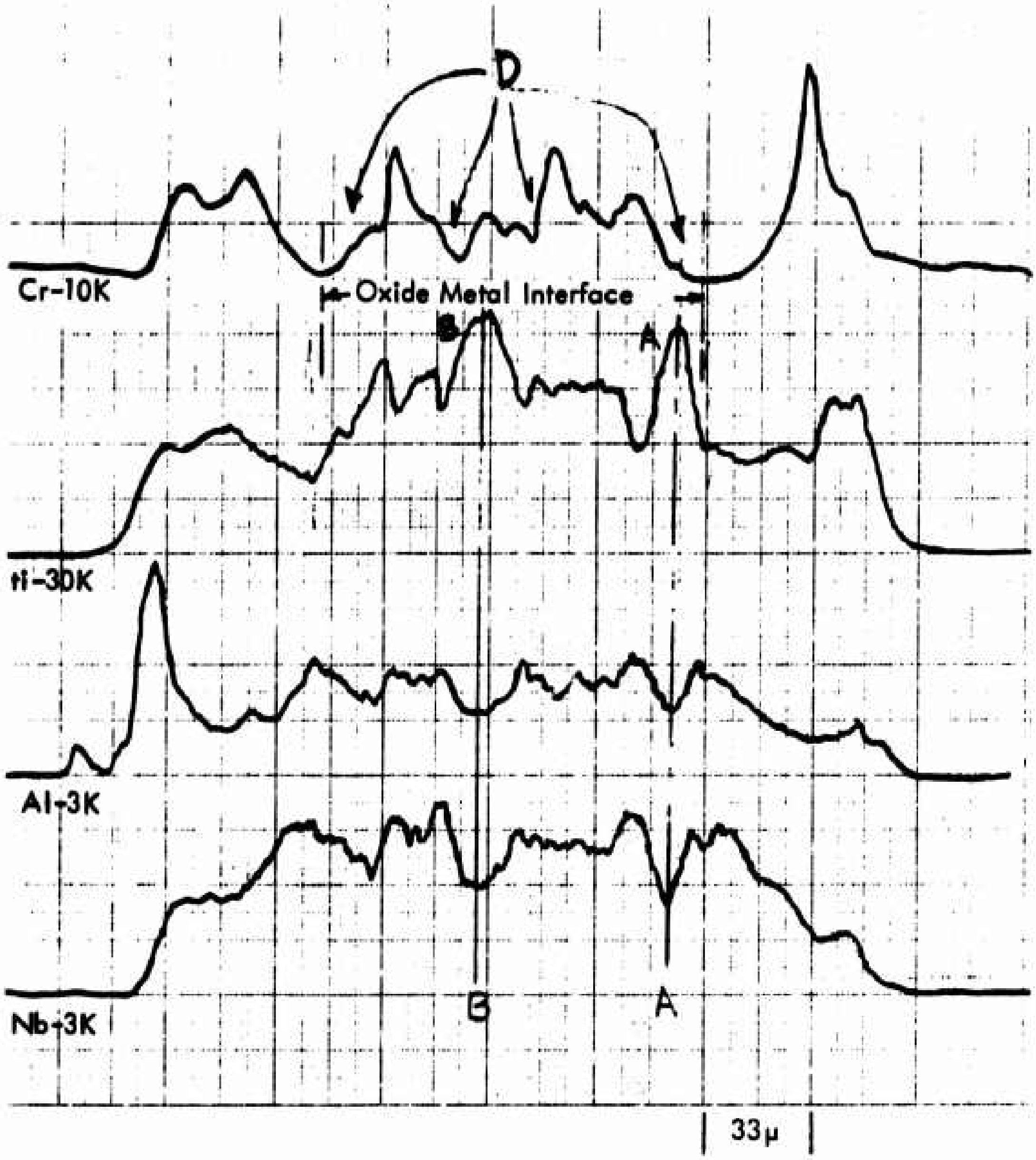


Figure 53g. Elemental Electron Microprobe Scans of Cr, Ti, Al, and Nb

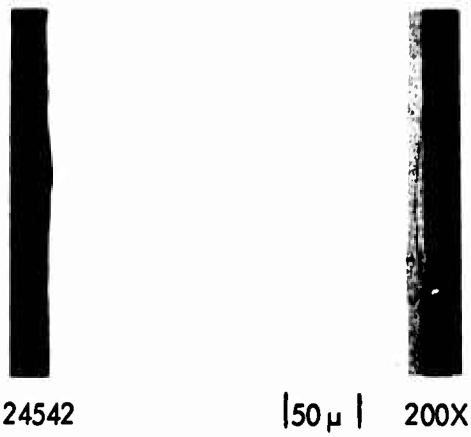
5.2 B-IV ALLOY: Nb-42Ti-4Cr-4Al-IV

Figures 54-57 show that the same general behavior, noted above for the J alloy, is found for the B-IV alloy. One weight percent vanadium was added to the alloy, and the chromium content was decreased. Microprobe traces were made, and of all the elements, the vanadium distribution was least affected by the oxidation exposure. As indicated in Figure 48, the B-IV alloy does oxidize at a faster rate. This is also shown by comparing the relative scale thickness of the J alloy and the B-IV alloy at comparable exposure conditions. The same relationship between areas rich in Cr, Nb, and Al and depleted in titanium are identical with that observed for the J-alloy as is shown by line A-A in Figure 56g. The mixing of chromium and titanium in the oxide is shown in Figure 57g at line A-A and B-B.

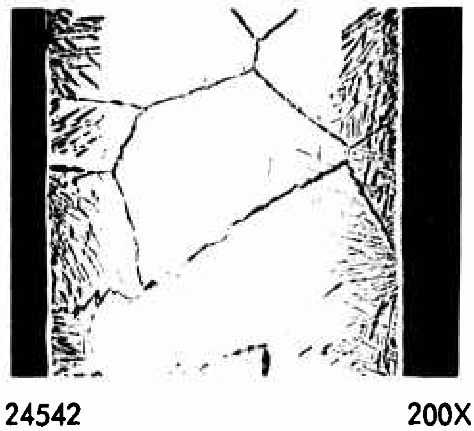
5.3 DISCUSSION OF RESULTS

From the microprobe results and metallographic examination it appears that both alloys behave similarly during elevated temperature exposure with the B-IV oxidizing at a faster rate than the J alloy. The x-ray data in Table II indicate the only observable difference between the oxides formed on the two alloys. In the J alloy a rutile oxide, $(Cr,Al)NbO_4$, is formed along with a $NbCr_2$ intermetallic. On the oxide formed in the B-IV alloy an additional oxide TiO_2-Nb_2O_5 is found along with the rutile structure and $NbCr_2$.

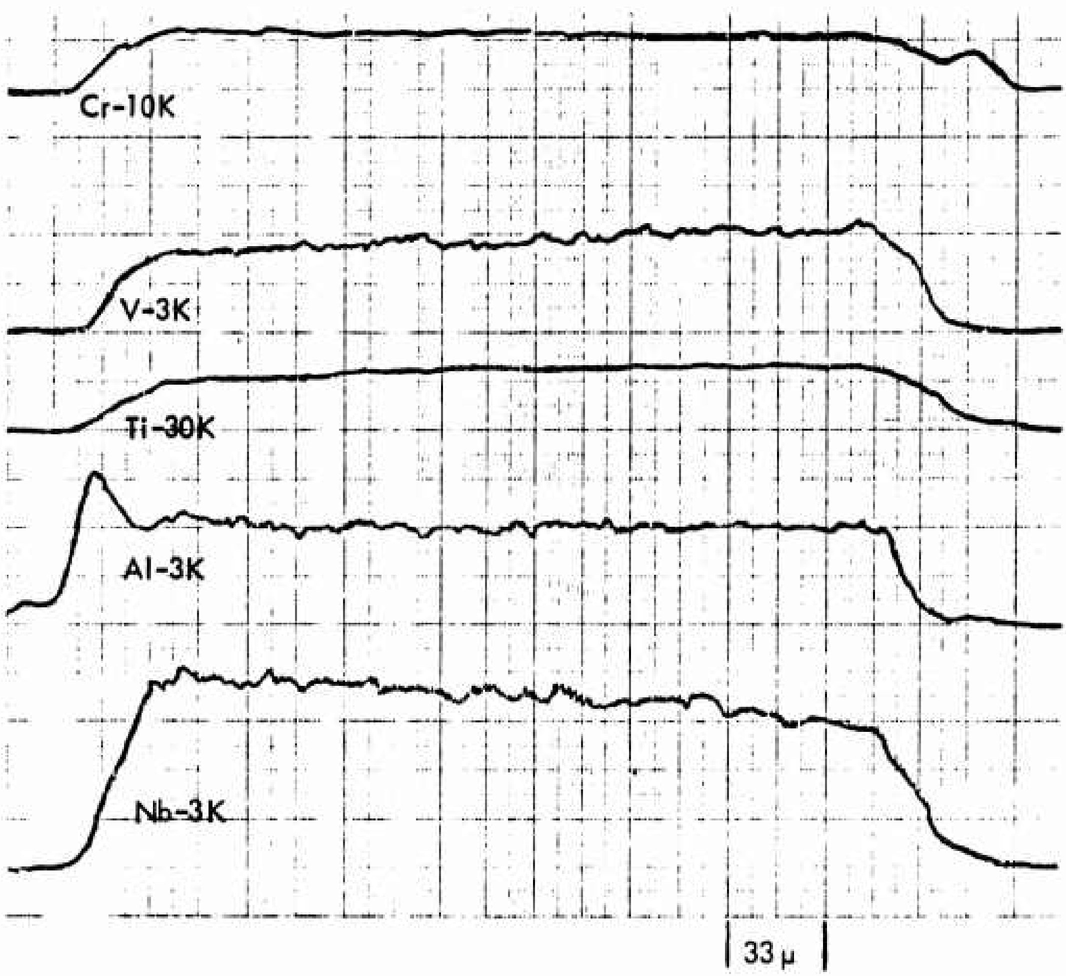
The oxygen diffusion measurements in the mixed niobates indicate that oxygen diffusion is slower in $CrNbO_4$ than in any other binary niobate tested thus far. Thus, it appears that the decrease in chromium content in the B-IV alloy allows some TiO_2-Nb_2O_5 oxide to form in the rutile (Cr,Al) NbO_4 and thus increases the rate of oxygen diffusion through the scale.



(a) As-polished



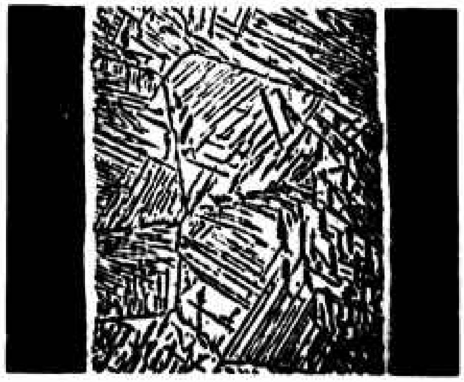
(b) As-etched



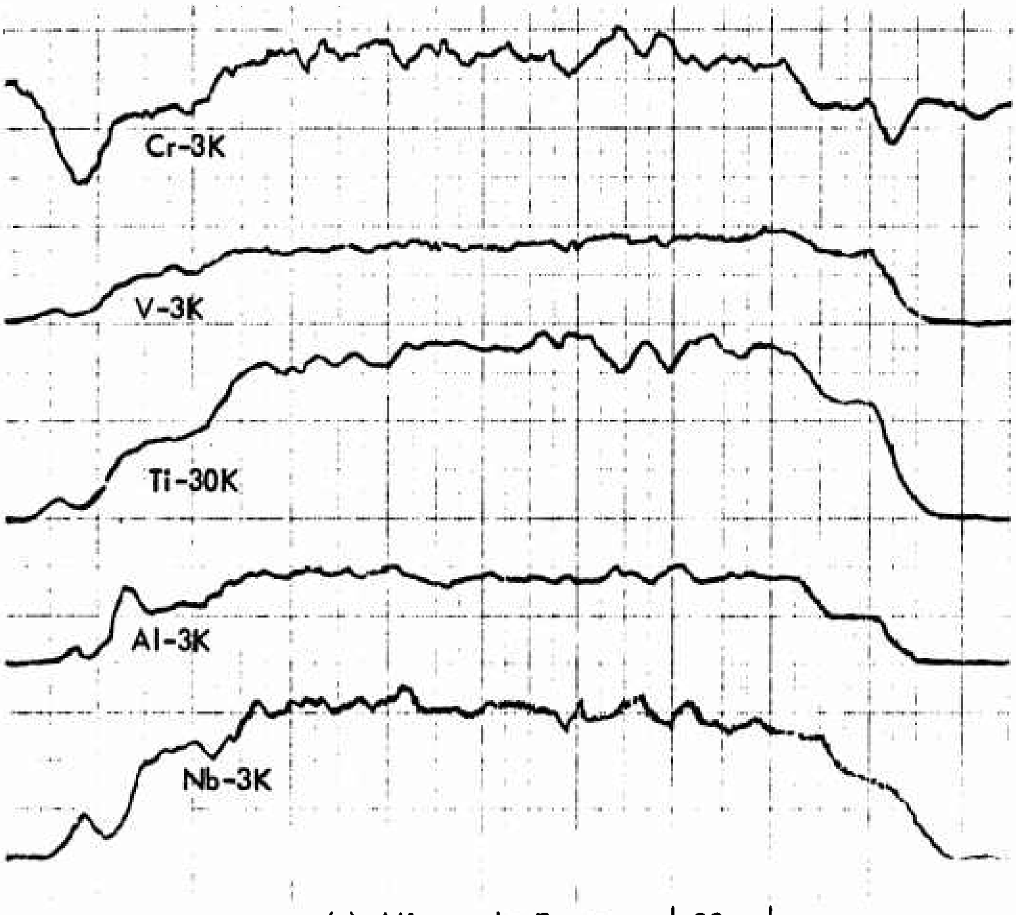
(c) Microprobe Traces

Figure 54. Microstructure, Oxide Scale, and Elemental Distribution for the Solar-B-IV Alloy after a 4 hour Air Oxidation Exposure at 1000°C

(a) As-polished

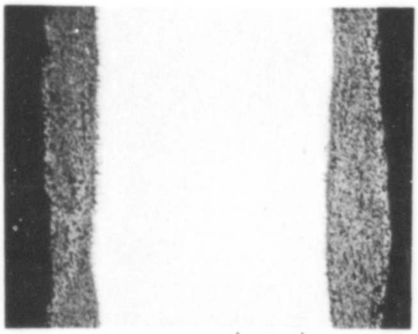


(b) As-etched



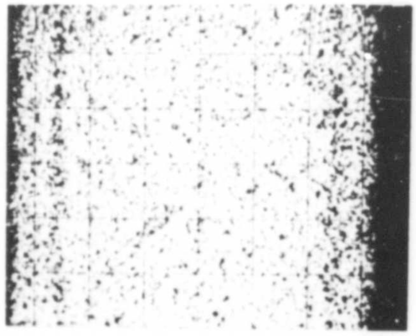
(c) Microprobe Traces

Figure 55. Microstructure, Oxide Scale, and Elemental Distribution for the Solar B-IV Alloy after a 16 hour Air Oxidation Exposure at 1000°C



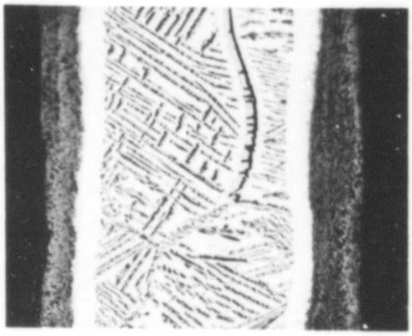
24544 |50 µ| 200X

(a) As-polished



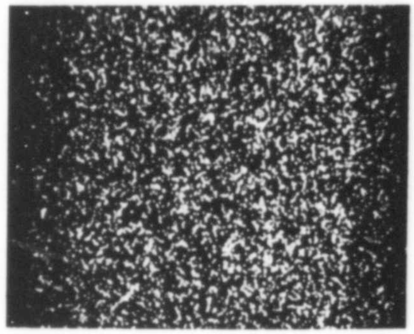
250X

(d) Titanium Distribution



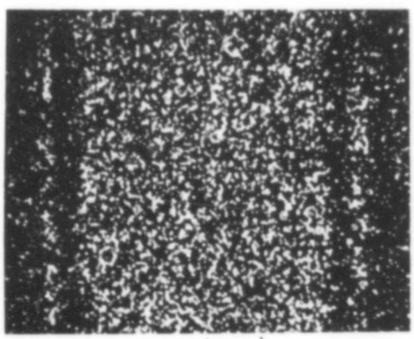
24544 200X

(b) As-etched



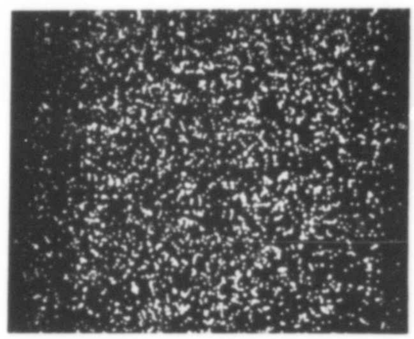
250X

(e) Niobium Distribution



|40µ| 250X

(c) Chromium Distribution



250X

(f) Aluminum Distribution

Figure 56. Microstructure, Oxide Scale, and Elemental Distribution for the Solar B-IV Alloy after a 4 hour Air Oxidation Exposure at 1200°C

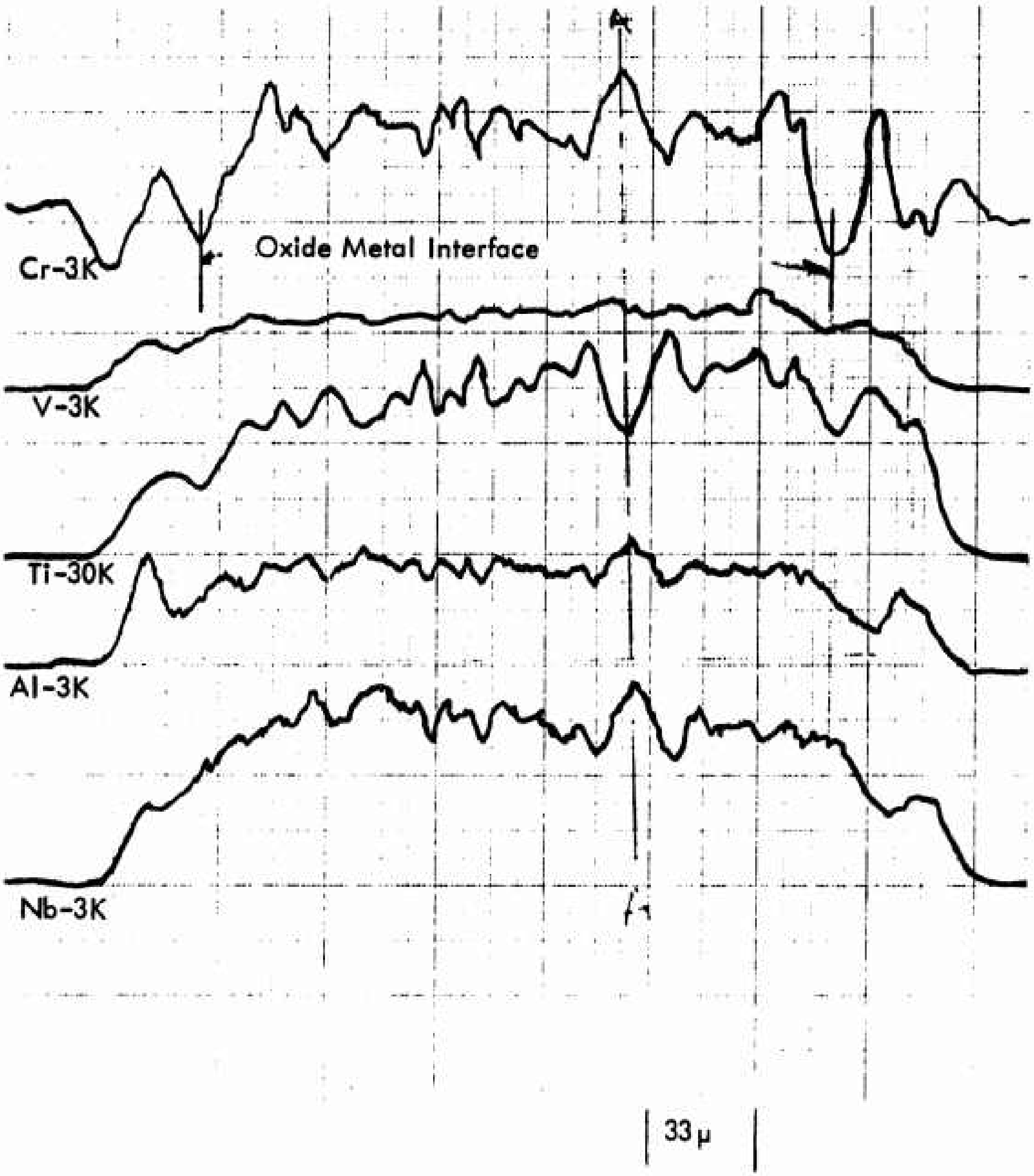
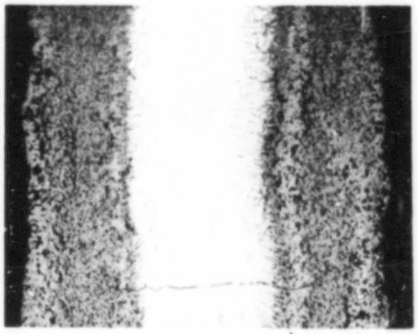
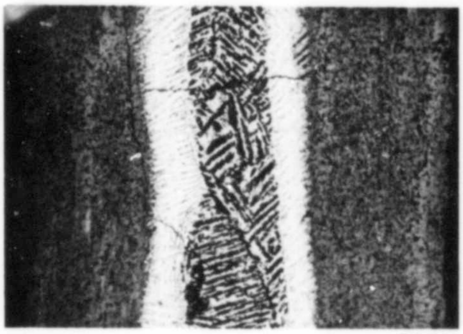


Figure 56g. Elemental Electron Microprobe Scans of Cr, V, Ti, Al, and Nb



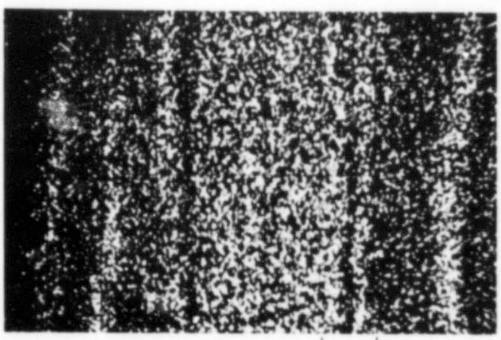
24545 50μ 200X

(a) As-polished



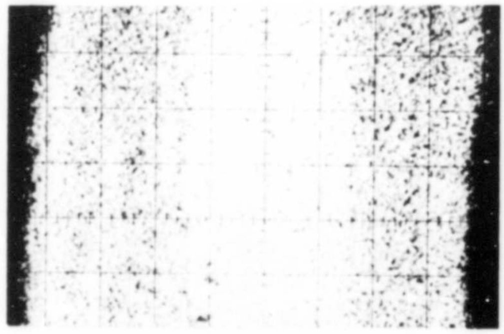
200X

(b) As-etched



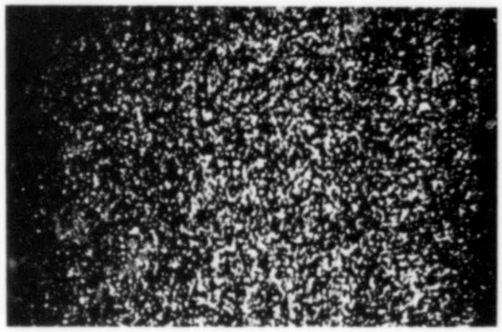
40μ 250X

(c) Chromium Distribution



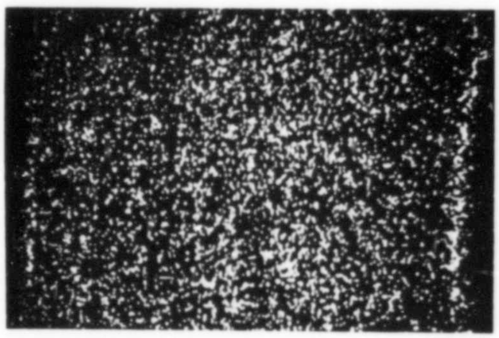
250X

(d) Titanium Distribution



250X

(e) Niobium Distribution



250X

(f) Aluminum Distribution

Figure 57. Microstructure, Oxide Scale, and Elemental Distribution for the Solar B-IV Alloy after a 16 hour air Oxidation Exposure at 1200°C

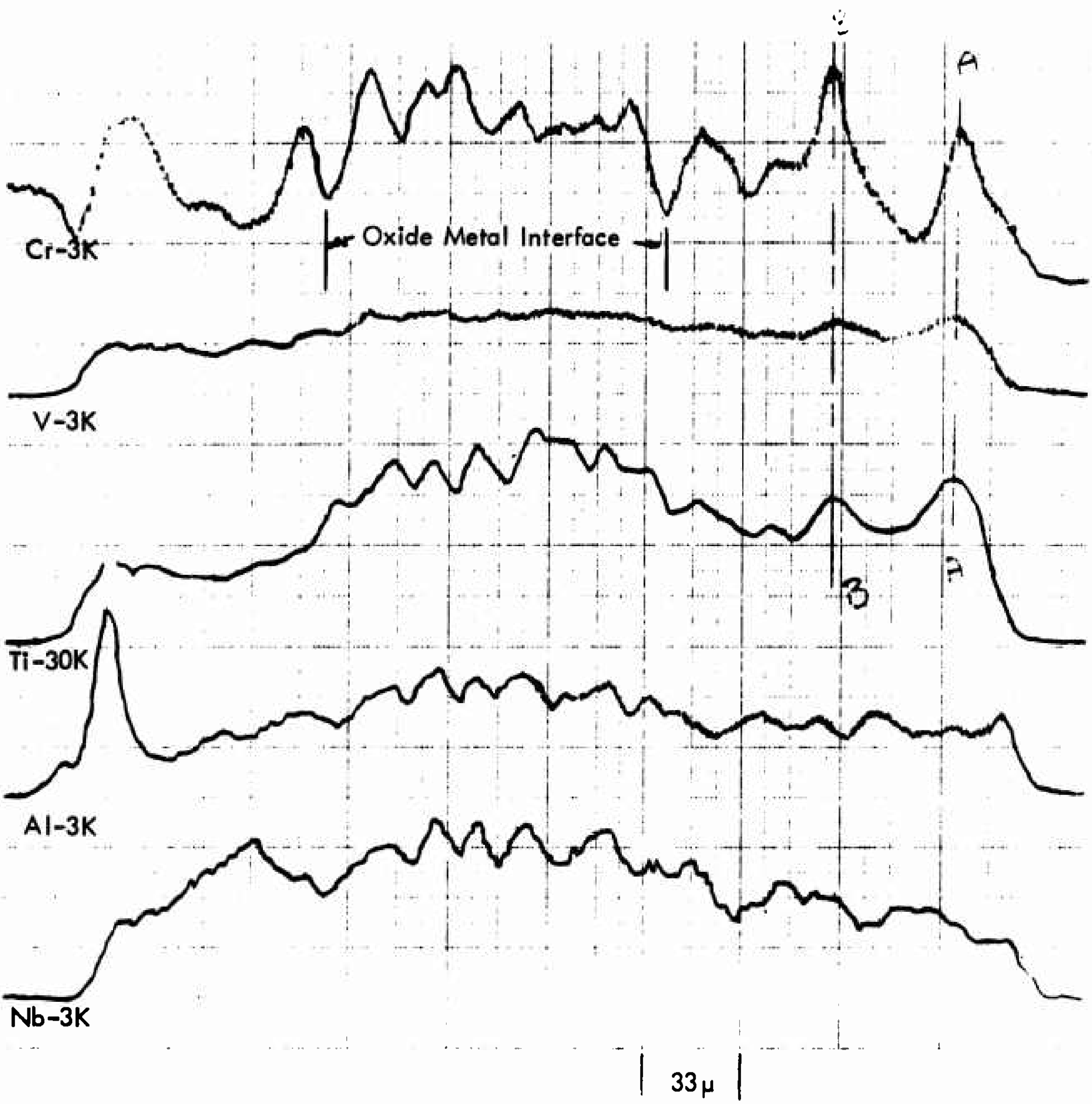


Figure 57g. Elemental Electron Microprobe Scans of Cr, V, Ti, Al, and Nb

Table II. Results of the Debye X-ray Diffraction Analysis of the Solar J and Solar B-IV Alloys After Oxidation

Alloy	Air Exposure		Phases Identified
	Time (hrs.)	Temp. (°C)	
J	4	1000	Strong matrix and very weak $NbCr_2$
	16	1000	Strong matrix, weak $NbCr_2$ and very weak rutile* structure.
	4	1200	Strong rutile*, a weak $NbCr_2$, and a very weak matrix.
	16	1200	Strong rutile*, and a medium $NbCr_2$
B-IV	4	1000	Strong matrix (B.C.C. with a_o 3.25 Å). Weak rutile* pattern and possibly a very weak $NbCr_2$.
	16	1000	Weak matrix, medium rutile*, weak Nb_2O_5-TiO_2, possibly $NbCr_2$
	4	1200	Strong rutile*, very weak matrix, and very weak $NbCr_2$
	16	1200	Strong rutile*, medium Nb_2O_5 - TiO_2, weak $NbCr_2$

* The rutile structure is a tetragonal structure (ASTM-20-311-$NbCrO_4$)

6.0 GENERAL DISCUSSION

This report has presented the oxidation behavior of Nb intermetallic compounds containing Cr, Al, and Fe Nb based alloys containing Cr-Al-Ni, Cr-Al-Co, Al-Fe, and the Solar alloys Ti-Cr-Al with and without vanadium. In every case the more protective scales contained a rutile phase $Nb(B)O_4$ where B = Fe, Cr, or Al and either a hematite type oxide B_2O_3 or a spinel $CoAl_2O_4$. In all scales that were nonprotective, the oxides showed additional phases present in the oxide. In the Nb based alloys, oxidation behavior is very complicated. It appears that aluminum is first internally oxidized as chromium is oxidized into the scale. The niobium apparently distributes itself evenly throughout all the particular phases. Nickel has very little effect on the structure of the scale, it being almost completely rejected back into the alloy as the more reactive components oxidize. Cobalt and aluminum form a spinel through which the cobalt diffusion is reported to be about 10^{-11} cm^2/sec at 1300°C[(2)].

From the oxygen diffusion data generated, only one of the rutile structures, particularly $CrNbO_4$, controlled oxygen diffusion enough to be considered protective. Yet in some other scales during similar x-ray diffraction patterns such as $AlNbO_4$ and TiO_2-Nb_2O_5 were part of the protective oxide layer. It is also possible that the B_2O_3-$Nb(B)O_4$ dual structure is required for oxidation protection, one of these two phases being required to form a protective scale. The oxidation rates of the DU-1, DU-2, and DU-4 alloys are low enough that they could be considered as potential high-temperature alloys for many specific applications such as short time-high performance engines and combustors. However, these alloys are very brittle and impossible to form in the as-melted state.

The compositional limits which govern the protective formation and growth of these oxides has yet to be defined. In addition, the phase equilibrium between the complex alloys and between the oxide phases has not been determined. In addition, the effect of reduced oxygen

partial pressures on the equilibrium structure of the mixed oxides is not understood. Until this data is available, it will not be possible to fully understand the interaction between a complex alloy, its oxide scale, and its oxygen environment. Goldschmidt[29] reports the considerable lattitude in lattice spacing, lattice defects, and ordering effects which can influence the diffusion properties of a rutile type structure, depending on cation composition and anion nonstoichiometry.

The discovery of the slow oxygen transport rate in $CrNbO_4$ confirms the selection by Mayo, et al[30] of $CrNbO_4$ as a protective oxide, although their selection was based on dilatometric data. Their work on 50-50 atomic % Cr-Nb alloys, however, revealed a Nb_2O_5 oxide in the scale as well as the $CrNbO_4$ phase. $CrNbO_4$ was shown formed on the intermetallic $NbCr_2$ compound. The Nb-Fe-Al DU-4 has not been previously touted as an oxygen resistant alloy, however, both the slow oxidation of $NbFe_2$ and the DU-4 alloy give credence to further investigation.

7.0 CONCLUSIONS

1. The oxide scales formed on the more oxidation resistant niobium based alloys investigated during this program all contained a rutile structure type oxide $Nb(B)O_4$ where B = Cr, Al, or Fe. In addition, a hematite B_2O_3 or a $CoAl_2O_4$ spinel was also found in the oxide scale along with the rutile phase.

2. The formation of any Nb_2O_5 oxides, identifiable by x-ray diffraction was associated with poor oxidation behavior.

3. Oxygen diffusion through Cr_2O_3-Nb_2O_5 was lower than that measured for the systems Al_2O_3-Nb_2O_5, HfO_2-Nb_2O_5, ZrO_2-Nb_2O_5, and TiO_2-Nb_2O_5.

4. A niobium based alloy, Nb-Cr-Al-Co and $NbAl_3$ exhibited parabolic oxidation constants as low as .037 - .018 $mg^2/cm^4/min$, respectively.

5. More work is needed to establish compositional phase relationships between the mixed niobates and oxygen partial pressure before a satisfactory definition of a protective oxide on Nb-based alloys can be provided. In addition, the alloy constitution-oxide constitution compositional relationships must be established so that the alloy compositions required to grow the protective oxides can be established.

8.0 REFERENCES

1. Svedberg, R. C., "Modification and Control of Oxide Structures on Metals and Alloys", WANL-PR(XXX)-001, April, 1971

2. Svedberg, R. C., "Modification and Control of Oxide Structures on Metals and Alloys", (II), WANL-FR-M-72-003, May, 1972

3. Kofstad, P., and Anderson, P. J., J. Phys, Chem. Solids, V. 21, p. 280 (1961)

4. Kopstad, P., J. Phys, Chem. Solids, V. 23, p. 1571 (1962)

5. Jannick, P. F., and Whitmore, D. H., J. Chem. Phys. V. 37, p. 2750, (1962)

6. Blumenthal, R. N., Moser, J. B., and Whitmore, D. H., J. Am. Ceram. Soc., V. 48, p. 617 (1965)

7. Bransky, I., Tallan, N. M., Wimmer, J. M., and Gviski, M., J. Am. Ceram. Soc., V. 54, No. 1, Jan. 1971

8. Levin, R. L., Wagner, J. B., Jr., Trans. AIME, V. 233 (1) p. 159 (1965)

9. Price, J. B., and Wagner, J. B., Jr., Z. Phys, Chem. (Frankfurt and Main), V. 49, p. 257, (1966)

10. Walters, L. C., and Grace, R. E., J. Phys, Chem. Solids. V. 28, p. 245, (1967)

11. Campbell, R. H., Koss, and Keeffe, M. O., "Mass Transport in Oxides", ed. J. B. Wachtman, Jr., and A. D. Franklin; Nat. Bur. Stand. (US), Spec. Publ., 296, (1968)

12. Lay, K. W., J. Amer. Ceram. Soc., V. 53, p. 369 (1970)

13. George, W. L., Grace, R. E., J. Phys, Chem. Solids, V. 30, 889 (1969)

14. Sheasby, J. S., Smeltzer, W. W., and Jenkins, A. E., J. Electrochem. Soc. V. 115, p. 338 (1968)

15. Wagner, J. B., Jr., Ib.d. No. 18, p. 65

16. Schäfer, H., Berguer, D., Gruehn, R., Z. Anorg. Allgem. Chem. V 365, 31 (1969)

17. Streiff, R., Poulton, D. J., Smeltzer, W. W., Oxid. of Metals, V.3, No. 1 (1971)

18. Wadsley, A. D., Acta Cript, V. 14, p. 660 (1961)

19. Crank, J., The Mathematics of Diffusion, Oxford Univ. Press, London, 1956

REFERENCES (Continued)

20. Paine, R. M., A. J. Stonehouse, and W. W. Beaver, W ADC TR 59-29, Parts I and II, PB Report 161, 683 (1960) U. S. Dept. Commerce, OTS.

21. Berkowitz Mattuck, J., and M. Rossetti, "Basic Factors Controlling Pest in High Temperature Systems", Final Report, Nov. 1971, NASA-CR-125071.

22. Aitken, E. A., "Corrosion Behavior in Intermetallic Compounds", in "Intermetallic Compounds", Ed. by Westbrook, John Wiley and Sons, N. Y., 1967, p. 491

23. Patent No. 2,882,146, April 14, 1959

24. Patent No. 2,838,395, June 10, 1958

25. Patent No. 2,881,069, April 7, 1959

26. Patent No. 2,838,396, June 10, 1958

27. Shunk, F. A., "Constitution of Binary Alloys, Second Supplement", McGraw-Hill, New York, 1969 pg. 180

28. Obtained from Dr. M. J. Klein, Solar Division of International Harvester Co., San Diego, California

29. Goldschmidt, H. J., "Interstitial Alloys," Plenum Press, New York, 1967, pp. 419-422

30. Mayo, G. T. J., W. H. Shephert, and A. G. Thomas, J. Less-Common Metals, v 2 (1960) 223.

APPENDIX A

DATA COMPILATION

The data gathered during these experiments are tabulated in Appendix A. The first two columns of the data sheets are the experimental data, time in seconds, and corrected weight loss in milligrams. The third column is the quantity $-\log(1 - M(t)/Q)$ when plotted as a function of time; the slope of this plot is used to determine the values of D for various oxides; $M(t)/Q$ in the sixth column is the ratio of the amount of oxygen lost at the specified time and divided by the total amount lost during the equilibration. The fourth column is a tabulation of the weight loss per area for the sample (mg/cm^2). The square of this value plotted as a function of time is found in the fifth column. The last column is the quantity time/$M(t)/A$.

Table CR-1. Weight Losses for 1.67:1.00 Mole Ratio Cr_2O_3-Nb_2O_5 Between the Oxygen Partial Pressure Range of 4.7×10^{-2} to 7.18×10^{-15} atm. at 850°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	-.0080	-.4734E-02	-.9988E-03	.9975E-06	.0108	-.6007E 05
120.	-.0320	-.1925E-01	-.3995E-02	.1596E-04	.0434	-.3004E 05
180.	-.0440	-.2670E-01	-.5493E-02	.3017E-04	.0596	-.3277E 05
240.	-.0440	-.2670E-01	-.5493E-02	.3017E-04	.0596	-.4369E 05
300.	-.0400	-.2420E-01	-.4994E-02	.2494E-04	.0542	-.6007E 05
360.	-.0400	-.2420E-01	-.4994E-02	.2494E-04	.0542	-.7209E 05
420.	-.0440	-.2670E-01	-.5493E-02	.3017E-04	.0596	-.7646E 05
480.	-.0480	-.2921E-01	-.5993E-02	.3591E-04	.0650	-.8010E 05
540.	-.0520	-.3173E-01	-.6492E-02	.4214E-04	.0705	-.8318E 05
600.	-.0640	-.3940E-01	-.7990E-02	.6384E-04	.0867	-.7509E 05
660.	-.0700	-.4328E-01	-.8739E-02	.7637E-04	.0949	-.7552E 05
720.	-.0840	-.5248E-01	-.1049E-01	.1100E-03	.1138	-.6866E [illegible]
780.	-.0960	-.6052E-01	-.1199E-01	.1436E-03	.1301	-.6508E 05
840.	-.1040	-.6597E-01	-.1298E-01	.1686E-03	.1409	-.6470E 05
900.	-.1120	-.7148E-01	-.1398E-01	.1955E-03	.1518	-.6437E 05
1200.	-.1280	-.8273E-01	-.1598E-01	.2554E-03	.1734	-.7509E 05
1500.	-.1640	-.1091E 00	-.2047E-01	.4192E-03	.2222	-.7326E 05
1800.	-.1760	-.1183E 00	-.2197E-01	.4828E-03	.2385	-.819 05
2400.	-.2160	-.1504E 00	-.2697E-01	.7272E-03	.2927	-.8900E 05
3000.	-.2600	-.1866E 00	-.3246E-01	.1054E-02	.3523	-.9242E 05
4140.	-.3000	-.2266E 00	-.3745E-01	.1403E-02	.4065	-.1105E 06
5400.	-.3680	-.2999E 00	-.4594E-01	.2111E-02	.4986	-.1175E 06
7200.	-.4300	-.3795E 00	-.5368E-01	.2882E-02	.5827	-.1341E 06
10800.	-.5000	-.4915E 00	-.6242E-01	.3897E-02	.6775	-.1730E 06
14400.	-.5120	-.5139E 00	-.6392E-01	.4086E-02	.6938	-.2253E 06
18000.	-.5520	-.5985E 00	-.6891E-01	.4749E-02	.7480	-.2612E 06
21600.	-.5760	-.6585E 00	-.7191E-01	.5171E-02	.7805	-.3004E 06
25200.	-.5680	-.6376E 00	-.7091E-01	.5028E-02	.7696	-.3554E 06
28800.	-.5810	-.6722E 00	-.7253E-01	.5261E-02	.7873	-.3971E 06
32400.	-.5920	-.7037E 00	-.7391E-01	.5462E-02	.8022	-.4384E 06
36000.	-.6040	-.7410E 00	-.7541E-01	.5686E-02	.8184	-.4774E 06
39600.	-.5920	-.7037E 00	-.7391E-01	.5462E-02	.8022	-.5358E 06
43200.	-.6080	-.7541E 00	-.7591E-01	.5762E-02	.8238	-.5691E 06
46800.	-.6120	-.7677E 00	-.7640E-01	.5838E-02	.8293	-.6125E 06
50400.	-.6440	-.8949E 00	-.8040E-01	.6464E-02	.8726	-.6269E 06
54000.	-.6600	-.9760E 00	-.8240E-01	.6789E-02	.8943	-.6554E 06
57600.	-.6760	-.1076E 01	-.8439E-01	.7122E-02	.9160	-.6825E 06
61200.	-.6840	-.1136E 01	-.8539E-01	.7292E-02	.9268	-.7167E 06
64800.	-.6880	-.1169E 01	-.8589E-01	.7378E-02	.9322	-.7544E 06
68400.	-.6960	-.1245E 01	-.8689E-01	.7550E-02	.9431	-.7872E 06
72000.	-.7040	-.1337E 01	-.8789E-01	.7725E-02	.9539	-.8192E 06
75600.	-.7160	-.1526E 01	-.8939E-01	.7990E-02	.9702	-.8457E 06
79200.	-.7340	-.2266E 01	-.9164E-01	.8397E-02	.9946	-.8643E 06
82800.	-.7360	-.2567E 01	-.9189E-01	.8443E-02	.9973	-.9011E 06

Table CR-2. Weight Losses for 1.67:1.00 Mole Ratio Cr_2O_3-Nb_2O_5 Between the Oxygen Partial Pressure Range of 7.18 x 10^{-15} to 4.42 x 10^{-17} atm. at 850°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	.0080	.5109E-02	.9988E-03	.9975E-06	-.0118	.6007E 05
120.	.0120	.7642E-02	.1498E-02	.2244E-05	-.0178	.8010E 05
180.	.0160	.1016E-01	.1998E-02	.3990E-05	-.0237	.9011E 05
240.	.0200	.1266E-01	.2497E-02	.6234E-05	-.0296	.9612E 05
300.	.0200	.1266E-01	.2497E-02	.6234E-05	-.0296	.1201E 06
360.	.0160	.1016E-01	.1998E-02	.3990E-05	-.0237	.1802E 06
420.	.0160	.1016E-01	.1998E-02	.3990E-05	-.0237	.2103E 06
480.	.0080	.5109E-02	.9988E-03	.9975E-06	-.0118	.4806E 06
540.	.0040	.2562E-02	.4994E-03	.2494E-06	-.0059	.1081E 07
600.	.0040	.2562E-02	.4994E-03	.2494E-06	-.0059	.1202E 07
660.	.0000	.0000E 00	.0000E 00	.0000E 00	.0000	.6600E 03
720.	-.0040	-.2577E-02	-.4994E-03	.2494E-06	.0059	-.1442E 07
780.	-.0040	-.2577E-02	-.4994E-03	.2494E-06	.0059	-.1562E 07
840.	-.0120	-.7779E-02	-.1498E-02	.2244E-05	.0178	-.5607E 06
900.	-.0160	-.1040E-01	-.1998E-02	.3990E-05	.0237	-.4506E 06
1200.	-.0240	-.1570E-01	-.2996E-02	.8978E-05	.0355	-.4005E 06
1500.	-.0080	-.5170E-02	-.9988E-03	.9975E-06	.0118	-.1502E 07
1800.	-.0200	-.1304E-01	-.2497E-02	.6234E-05	.0296	-.7209E 06
2400.	-.0520	-.3476E-01	-.6492E-02	.4214E-04	.0769	-.3697E 06
3000.	-.0840	-.5762E-01	-.1049E-01	.1100E-03	.1243	-.2861E 06
4140.	-.1040	-.7255E-01	-.1296E-01	.1686E-03	.1538	-.3169E 06
5400.	-.1440	-.1040E 00	-.1798E-01	.3232E-03	.2130	-.3004E 06
7200.	-.1920	-.1451E 00	-.2397E-01	.5746E-03	.2840	-.3004E 06
10800.	-.2720	-.2236E 00	-.3396E-01	.1153E-02	.4024	-.3180E 06
14400.	-.3000	-.2548E 00	-.3745E-01	.1403E-02	.4438	-.3845E 06
18000.	-.3320	-.2934E 00	-.4145E-01	.1718E-02	.4911	-.4343E 06
21600.	-.3680	-.3414E 00	-.4594E-01	.2111E-02	.5444	-.4702E 06
25200.	-.3960	-.3828E 00	-.4944E-01	.2444E-02	.5858	-.5097E 06
28800.	-.4160	-.4150E 00	-.5194E-01	.2697E-02	.6154	-.5545E 06
32400.	-.4320	-.4426E 00	-.5393E-01	.2909E-02	.6391	-.6007E 06
36000.	-.4720	-.5203E 00	-.5893E-01	.3472E-02	.6982	-.6109E 06
39600.	-.4960	-.5747E 00	-.6192E-01	.3834E-02	.7337	-.6395E 06
43200.	-.5120	-.6151E 00	-.6392E-01	.4086E-02	.7574	-.6758E 06
46800.	-.5360	-.6838E 00	-.6692E-01	.4478E-02	.7929	-.6994E 06
50400.	-.5520	-.7365E 00	-.6891E-01	.4749E-02	.8166	-.7313E 06
54000.	-.5760	-.8299E 00	-.7191E-01	.5171E-02	.8521	-.7509E 06
57600.	-.5920	-.9057E 00	-.7391E-01	.5462E-02	.8757	-.7794E 06
61200.	-.6120	-.1024E 01	-.7640E-01	.5838E-02	.9053	-.8010E 06
64800.	-.6400	-.1274E 01	-.7990E-01	.6384E-02	.9467	-.8110E 06
68400.	-.6640	-.1751E 01	-.8290E-01	.6872E-02	.9822	-.8251E 06
72000.	-.6720	-.2228E 01	-.8390E-01	.7036E-02	.9941	-.8582E 06

Table CR-3. Weight Losses for 1.67:1.00 Mole Ratio Cr_2O_3-Nb_2O_5 Between the Oxygen Partial Pressure Range of 4.42×10^{-17} to 4.25×10^{-18} atm. at 850°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	-.0040	-.4349E-03	-.4994E-03	.2494E-06	.0010	-.1201E 06
120.	.0120	.1302E-02	.1498E-02	.2244E-05	-.0030	.8010E 05
180.	.0120	.1302E-02	.1498E-02	.2244E-05	-.0030	.1201E 06
240.	.0080	.8686E-03	.9988E-03	.9975E-06	-.0020	.2403E 06
300.	.0080	.8686E-03	.9988E-03	.9975E-06	-.0020	.3004E 06
360.	-.0040	-.4349E-03	-.4994E-03	.2494E-06	.0010	-.7209E 06
420.	-.0120	-.1306E-02	-.1498E-02	.2244E-05	.0030	-.2803E 06
480.	-.0200	-.2179E-02	-.2497E-02	.6234E-05	.0050	-.1922E 06
540.	-.0240	-.2616E-02	-.2996E-02	.8978E-05	.0060	-.1802E 06
600.	-.0360	-.3930E-02	-.4494E-02	.2020E-04	.0090	-.1335E 06
660.	-.0400	-.4369E-02	-.4994E-02	.2494E-04	.0100	-.1322E 06
720.	-.0440	-.4809E-02	-.5493E-02	.3017E-04	.0110	-.1311E 06
780.	-.0480	-.5248E-02	-.5993E-02	.3591E-04	.0120	-.1302E 06
840.	-.0600	-.6570E-02	-.7491E-02	.5611E-04	.0150	-.1121E 06
900.	-.0640	-.7012E-02	-.7990E-02	.6384E-04	.0160	-.1126E 06
1200.	-.1040	-.1145E-01	-.1298E-01	.1686E-03	.0260	-.9242E 05
1500.	-.1280	-.1414E-01	-.1598E-01	.2554E-03	.0320	-.9387E 05
1800.	-.1520	-.1684E-01	-.1898E-01	.3601E-03	.0380	-.9486E 05
2400.	-.1640	-.1820E-01	-.2047E-01	.4192E-03	.0410	-.1172E 06
3000.	-.2080	-.2322E-01	-.2597E-01	.6743E-03	.0521	-.1155E 06
4140.	-.2320	-.2598E-01	-.2896E-01	.8389E-03	.0581	-.1429E 06
5400.	-.3120	-.3531E-01	-.3895E-01	.1517E-02	.0781	-.1386E 06
7200.	-.3760	-.4292E-01	-.4694E-01	.2203E-02	.0941	-.1534E 06
10800.	-.5160	-.6005E-01	-.6442E-01	.4150E-02	.1291	-.1677E 06
14400.	-.6200	-.7322E-01	-.7740E-01	.5991E-02	.1552	-.1860E 06
18000.	-.7160	-.8575E-01	-.8939E-01	.7990E-02	.1792	-.2014E 06
21600.	-.8200	-.9974E-01	-.1024E 00	.1048E-01	.2052	-.2110E 06
25200.	-.8960	-.1103E 00	-.1119E 00	.1251E-01	.2242	-.2253E 06
28800.	-1.0720	-.1356E 00	-.1338E 00	.1791E-01	.2683	-.2152E 06
32400.	-1.0800	-.1368E 00	-.1348E 00	.1818E-01	.2703	-.2403E 06
36000.	-1.1920	-.1538E 00	-.1488E 00	.2215E-01	.2983	-.2419E 06
39600.	-1.2400	-.1613E 00	-.1548E 00	.2397E-01	.3103	-.2558E 06
43200.	-1.3040	-.1716E 00	-.1628E 00	.2650E-01	.3263	-.2654E 06
46800.	-1.3760	-.1833E 00	-.1718E 00	.2951E-01	.3443	-.2724E 06
50400.	-1.4480	-.1954E 00	-.1808E 00	.3268E-01	.3624	-.2788E 06
54000.	-1.5160	-.2072E 00	-.1893E 00	.3582E-01	.3794	-.2853E 06
57600.	-1.6000	-.2221E 00	-.1998E 00	.3990E-01	.4004	-.2884E 06
61200.	-1.6600	-.2332E 00	-.2072E 00	.4295E-01	.4154	-.2953E 06
64800.	-1.7200	-.2445E 00	-.2147E 00	.4611E-01	.4304	-.3018E 06
68400.	-1.7800	-.2561E 00	-.2222E 00	.4938E-01	.4454	-.3078E 06

Table CR-3 (Continued)

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
72000.	-1.8320	-.2664E 00	-.2287E 00	.5231E-01	.4585	-.3148E 06
75600.	-1.9040	-.2811E 00	-.2377E 00	.5650E-01	.4765	-.3180E 06
79200.	-1.9600	-.2928E 00	-.2447E 00	.5988E-01	.4905	-.3237E 06
82800.	-2.0120	-.3041E 00	-.2512E 00	.6309E-01	.5035	-.3296E 06
86400.	-2.0800	-.3192E 00	-.2597E 00	.6743E-01	.5205	-.3327E 06
90000.	-2.1360	-.3321E 00	-.2667E 00	.7111E-01	.5345	-.3375E 06
93600.	-2.2320	-.3551E 00	-.2787E 00	.7765E-01	.5586	-.3359E 06
97200.	-2.3720	-.3910E 00	-.2961E 00	.8769E-01	.5936	-.3282E 06
100800.	-2.3760	-.3921E 00	-.2966E 00	.8799E-01	.5946	-.3398E 06
104400.	-2.4320	-.4074E 00	-.3036E 00	.9219E-01	.6086	-.3439E 06
108000.	-2.5040	-.4279E 00	-.3126E 00	.9772E-01	.6266	-.3455E 06
111600.	-2.5720	-.4481E 00	-.3211E 00	.1031E 00	.6436	-.3476E 06
115200.	-2.6320	-.4668E 00	-.3286E 00	.1080E 00	.6587	-.3506E 06
118800.	-2.6800	-.4824E 00	-.3346E 00	.1119E 00	.6707	-.3551E 06
122400.	-2.7280	-.4985E 00	-.3406E 00	.1160E 00	.6827	-.3594E 06
126000.	-2.7840	-.5181E 00	-.3476E 00	.1208E 00	.6967	-.3625E 06
129600.	-2.8320	-.5357E 00	-.3536E 00	.1250E 00	.7087	-.3666E 06
133200.	-2.8560	-.5447E 00	-.3566E 00	.1271E 00	.7147	-.3736E 06
136800.	-2.9040	-.5634E 00	-.3625E 00	.1314E 00	.7267	-.3773E 06
140400.	-2.9600	-.5863E 00	-.3695E 00	.1366E 00	.7407	-.3799E 06
144000.	-2.9920	-.5999E 00	-.3735E 00	.1395E 00	.7487	-.3855E 06
147600.	-3.0320	-.6175E 00	-.3785E 00	.1433E 00	.7568	-.3899E 06
151200.	-3.0920	-.6455E 00	-.3860E 00	.1490E 00	.7738	-.3917E 06
154800.	-3.1240	-.6611E 00	-.3900E 00	.1521E 00	.7818	-.3969E 06
158400.	-3.1840	-.6921E 00	-.3975E 00	.1580E 00	.7968	-.3985E 06
162000.	-3.2280	-.7163E 00	-.4030E 00	.1624E 00	.8078	-.4020E 06
165600.	-3.2680	-.7395E 00	-.4080E 00	.1665E 00	.8178	-.4059E 06
169200.	-3.3120	-.7666E 00	-.4135E 00	.1710E 00	.8288	-.4092E 06
172800.	-3.3680	-.8037E 00	-.4205E 00	.1768E 00	.8428	-.4110E 06
176400.	-3.4480	-.8628E 00	-.4305E 00	.1853E 00	.8629	-.4098E 06
180000.	-3.5000	-.9061E 00	-.4370E 00	.1909E 00	.8759	-.4119E 06
183600.	-3.5520	-.9542E 00	-.4434E 00	.1966E 00	.8889	-.4140E 06
187200.	-3.5960	-.9996E 00	-.4489E 00	.2015E 00	.8999	-.4170E 06
190800.	-3.6480	-.1060E 01	-.4554E 00	.2074E 00	.9129	-.4189E 06
194400.	-3.7120	-.1148E 01	-.4634E 00	.2148E 00	.9289	-.4195E 06
198000.	-3.7520	-.1214E 01	-.4684E 00	.2194E 00	.9389	-.4227E 06
201600.	-3.7960	-.1301E 01	-.4739E 00	.2246E 00	.9499	-.4254E 06
205200.	-3.8320	-.1387E 01	-.4784E 00	.2289E 00	.9590	-.4289E 06
208800.	-3.8720	-.1508E 01	-.4834E 00	.2337E 00	.9690	-.4319E 06
212400.	-3.9120	-.1677E 01	-.4884E 00	.2385E 00	.9790	-.4349E 06
216000.	-3.9620	-.2070E 01	-.4946E 00	.2447E 00	.9915	-.4367E 06
219600.	-3.9920	-.3000E 01	-.4984E 00	.2484E 00	.9990	-.4406E 06

Table CR-4. Weight Losses for 1.67:1.00 Mole Ratio Cr_2O_3-Nb_2O_5 Between the Oxygen Partial Pressure Range of 5.7×10^{-2} to 3.17×10^{-11} atm. at 1000°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	-.0080	-.1011E-02	-.9988E-03	.9975E-06	.0023	-.6007E 05
120.	-.0160	-.2025E-02	-.1998E-02	.3990E-05	.0047	-.6007E 05
180.	-.0200	-.2532E-02	-.2497E-02	.6234E-05	.0058	-.7209E 05
240.	-.0320	-.4059E-02	-.3995E-02	.1596E-04	.0093	-.6007E 05
300.	-.0600	-.7642E-02	-.7491E-02	.5611E-04	.0174	-.4005E 05
360.	-.0880	-.1125E-01	-.1099E-01	.1207E-03	.0256	-.3277E 05
420.	-.1180	-.1516E-01	-.1473E-01	.2170E-03	.0343	-.2851E 05
480.	-.1320	-.1699E-01	-.1648E-01	.2716E-03	.0384	-.2913E 05
540.	-.1520	-.1963E-01	-.1898E-01	.3601E-03	.0442	-.2846E 05
600.	-.1680	-.2175E-01	-.2097E-01	.4399E-03	.0488	-.2861E 05
660.	-.1840	-.2387E-01	-.2297E-01	.5277E-03	.0535	-.2873E 05
720.	-.2000	-.2601E-01	-.2497E-01	.6234E-03	.0581	-.2884E 05
780.	-.2220	-.2897E-01	-.2772E-01	.7681E-03	.0645	-.2814E 05
840.	-.2320	-.3052E-01	-.2896E-01	.8389E-03	.0674	-.2900E 05
900.	-.2480	-.3250E-01	-.3096E-01	.9586E-03	.0721	-.2907E 05
1200.	-.2880	-.3797E-01	-.3596E-01	.1293E-02	.0837	-.3337E 05
1500.	-.3360	-.4464E-01	-.4195E-01	.1760E-02	.0977	-.3576E 05
1800.	-.3700	-.4942E-01	-.4619E-01	.2134E-02	.1076	-.3897E 05
2400.	-.4380	-.5915E-01	-.5468E-01	.2990E-02	.1273	-.4389E 05
3000.	-.5000	-.6821E-01	-.6242E-01	.3897E-02	.1453	-.4806E 05
4140.	-.5600	-.7717E-01	-.6991E-01	.4888E-02	.1628	-.5922E 05
5400.	-.7120	-.1007E 00	-.8889E-01	.7901E-02	.2070	-.6075E 05
7200.	-.8520	-.1236E 00	-.1064E 00	.1131E-01	.2477	-.6769E 05
10800.	-1.0560	-.1593E 00	-.1318E 00	.1738E-01	.3070	-.8192E 05
14400.	-1.2280	-.1918E 00	-.1533E 00	.2350E-01	.3570	-.9393E 05
18000.	-1.3880	-.2244E 00	-.1733E 00	.3003E-01	.4035	-.1039E 06
21600.	-1.5080	-.2506E 00	-.1883E 00	.3544E-01	.4384	-.1147E 06
25200.	-1.6280	-.2764E 00	-.2032E 00	.4131E-01	.4733	-.1240E 06
28800.	-1.7280	-.3031E 00	-.2157E 00	.4654E-01	.5023	-.1335E 06
32400.	-1.7960	-.3207E 00	-.2242E 00	.5027E-01	.5221	-.1445E 06
36000.	-1.8760	-.3423E 00	-.2342E 00	.5485E-01	.5453	-.1537E 06
39600.	-1.9480	-.3628E 00	-.2432E 00	.5914E-01	.5663	-.1628E 06
43200.	-1.9880	-.3746E 00	-.2482E 00	.6160E-01	.5779	-.1741E 06
46800.	-2.0560	-.3954E 00	-.2567E 00	.6588E-01	.5977	-.1823E 06
50400.	-2.1160	-.4147E 00	-.2642E 00	.6979E-01	.6151	-.1908E 06
54000.	-2.1960	-.4417E 00	-.2742E 00	.7516E-01	.6384	-.1970E 06
57600.	-2.2360	-.4559E 00	-.2792E 00	.7793E-01	.6500	-.2063E 06
61200.	-2.2920	-.4766E 00	-.2861E 00	.8188E-01	.6663	-.2139E 06
64800.	-2.3240	-.4889E 00	-.2901E 00	.8418E-01	.6756	-.2233E 06
68400.	-2.3720	-.5080E 00	-.2961E 00	.8769E-01	.6895	-.2310E 06

Table C-4 (Continued)

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
72000.	-2.4160	-.5263E 00	-.3016E 00	.9098E-01	.7023	-.2387E 06
75600.	-2.4560	-.5436E 00	-.3066E 00	.9401E-01	.7140	-.2466E 06
79200.	-2.4920	-.5598E 00	-.3111E 00	.9679E-01	.7244	-.2546E 06
82800.	-2.5480	-.5862E 00	-.3181E 00	.1012E 00	.7407	-.2603E 06
86400.	-2.5720	-.5980E 00	-.3211E 00	.1031E 00	.7477	-.2691E 06
90000.	-2.6080	-.6164E 00	-.3256E 00	.1060E 00	.7561	-.2764E 06
93600.	-2.6520	-.6400E 00	-.3311E 00	.1096E 00	.7709	-.2827E 06
97200.	-2.7080	-.6720E 00	-.3381E 00	.1143E 00	.7872	-.2875E 06
100800.	-2.7480	-.6965E 00	-.3431E 00	.1177E 00	.7988	-.2938E 06
104400.	-2.7800	-.7170E 00	-.3471E 00	.1205E 00	.8081	-.3008E 06
108000.	-2.8040	-.7331E 00	-.3501E 00	.1225E 00	.8151	-.3085E 06
111600.	-2.8520	-.7672E 00	-.3561E 00	.1268E 00	.8291	-.3134E 06
115200.	-2.8760	-.7853E 00	-.3591E 00	.1289E 00	.8360	-.3208E 06
118800.	-2.8840	-.7915E 00	-.3600E 00	.1296E 00	.8384	-.3300E 06
122400.	-2.9120	-.8139E 00	-.3635E 00	.1322E 00	.8465	-.3367E 06
126000.	-2.9320	-.8307E 00	-.3660E 00	.1340E 00	.8523	-.3442E 06
129600.	-2.9320	-.8307E 00	-.3660E 00	.1340E 00	.8523	-.3541E 06
133200.	-2.9400	-.8376E 00	-.3670E 00	.1347E 00	.8547	-.3629E 06
136800.	-2.9560	-.8517E 00	-.3690E 00	.1362E 00	.8593	-.3707E 06
140400.	-2.9640	-.8590E 00	-.3700E 00	.1369E 00	.8616	-.3794E 06
144000.	-2.9880	-.8814E 00	-.3730E 00	.1392E 00	.8686	-.3860E 06
147600.	-2.9960	-.8892E 00	-.3740E 00	.1399E 00	.8709	-.3946E 06
151200.	-3.0120	-.9051E 00	-.3760E 00	.1414E 00	.8756	-.4021E 06
154800.	-3.0120	-.9051E 00	-.3760E 00	.1414E 00	.8756	-.4117E 06
158400.	-3.0280	-.9217E 00	-.3780E 00	.1429E 00	.8802	-.4190E 06
162000.	-3.0480	-.9433E 00	-.3805E 00	.1448E 00	.8860	-.4257E 06
165600.	-3.0680	-.9660E 00	-.3830E 00	.1467E 00	.8919	-.4324E 06
169200.	-3.0680	-.9660E 00	-.3830E 00	.1467E 00	.8919	-.4418E 06
172800.	-3.0680	-.9660E 00	-.3830E 00	.1467E 00	.8919	-.4511E 06
176400.	-3.0880	-.9900E 00	-.3855E 00	.1486E 00	.8977	-.4576E 06
180000.	-3.1160	-.1026E 01	-.3890E 00	.1513E 00	.9058	-.4627E 06
183600.	-3.1560	-.1083E 01	-.3940E 00	.1552E 00	.9174	-.4660E 06
187200.	-3.1720	-.1108E 01	-.3960E 00	.1568E 00	.9221	-.4727E 06
190800.	-3.1960	-.1149E 01	-.3990E 00	.1592E 00	.9291	-.4782E 06
194400.	-3.2040	-.1164E 01	-.4000E 00	.1600E 00	.9314	-.4860E 06
198000.	-3.2280	-.1210E 01	-.4030E 00	.1624E 00	.9384	-.4913E 06
201600.	-3.2440	-.1244E 01	-.4050E 00	.1640E 00	.9430	-.4978E 06
205200.	-3.2600	-.1281E 01	-.4070E 00	.1656E 00	.9477	-.5042E 06
208800.	-3.2680	-.1301E 01	-.4080E 00	.1665E 00	.9500	-.5118E 06
212400.	-3.2600	-.1281E 01	-.4070E 00	.1656E 00	.9477	-.5219E 06

Table CR-4 (Continued)

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
216000.	-3.2440	-.1244E 01	-.4050E 00	.1640E 00	.9430	-.5333E 06
219600.	-3.2280	-.1210E 01	-.4030E 00	.1624E 00	.9384	-.5449E 06
223200.	-3.2280	-.1210E 01	-.4030E 00	.1624E 00	.9384	-.5539E 06
226800.	-3.2280	-.1210E 01	-.4030E 00	.1624E 00	.9384	-.5628E 06
230400.	-3.2480	-.1253E 01	-.4055E 00	.1644E 00	.9442	-.5682E 06
234000.	-3.2440	-.1244E 01	-.4050E 00	.1640E 00	.9430	-.5778E 06
237600.	-3.2600	-.1281E 01	-.4070E 00	.1656E 00	.9477	-.5838E 06
241200.	-3.2680	-.1301E 01	-.4080E 00	.1665E 00	.9500	-.5912E 06
244800.	-3.2680	-.1301E 01	-.4080E 00	.1665E 00	.9500	-.6000E 06
248400.	-3.2680	-.1301E 01	-.4080E 00	.1665E 00	.9500	-.6088E 06
252000.	-3.2720	-.1311E 01	-.4085E 00	.1669E 00	.9512	-.6169E 06
255600.	-3.2760	-.1322E 01	-.4090E 00	.1673E 00	.9523	-.6250E 06
259200.	-3.2720	-.1311E 01	-.4085E 00	.1669E 00	.9512	-.6345E 06
262800.	-3.2760	-.1322E 01	-.4090E 00	.1673E 00	.9523	-.6426E 06
266400.	-3.3240	-.1472E 01	-.4150E 00	.1722E 00	.9663	-.6420E 06
270000.	-3.3440	-.1554E 01	-.4175E 00	.1743E 00	.9721	-.6467E 06
273600.	-3.3720	-.1704E 01	-.4210E 00	.1772E 00	.9802	-.6499E 06
277200.	-3.3880	-.1821E 01	-.4230E 00	.1789E 00	.9849	-.6554E 06
280800.	-3.4200	-.2236E 01	-.4270E 00	.1823E 00	.9942	-.6577E 06
284400.	-3.4360	-.2934E 01	-.4290E 00	.1840E 00	.9988	-.6630E 06

Table CR-5. Weight Losses for 1.67:1.00 Mole Ratio Cr_2O_3-Nb_2O_5 Between the Oxygen Partial Pressure Range of 3.17×10^{-11} to 4.70×10^{-14} atm. at 1000°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	-.0080	-.2831E-03	-.9988E-03	.9975E-06	.0007	-.6007E 05
120.	-.0120	-.4247E-03	-.1498E-02	.2244E-05	.0010	-.8010E 05
180.	-.0240	-.8499E-03	-.2996E-02	.8978E-05	.0020	-.6007E 05
240.	-.0360	-.1275E-02	-.4494E-02	.2020E-04	.0029	-.5340E 05
300.	-.0480	-.1701E-02	-.5993E-02	.3591E-04	.0039	-.5006E 05
360.	-.0720	-.2555E-02	-.8989E-02	.8080E-04	.0059	-.4005E 05
420.	-.0880	-.3124E-02	-.1099E-01	.1207E-03	.0072	-.3823E 05
480.	-.1160	-.4123E-02	-.1448E-01	.2097E-03	.0094	-.3314E 05
540.	-.1320	-.4695E-02	-.1648E-01	.2716E-03	.0108	-.3277E 05
600.	-.1480	-.5268E-02	-.1848E-01	.3414E-03	.0121	-.3247E 05
660.	-.1680	-.5984E-02	-.2097E-01	.4399E-03	.0137	-.3147E 05
720.	-.1800	-.6415E-02	-.2247E-01	.5050E-03	.0147	-.3204E 05
780.	-.1960	-.6990E-02	-.2447E-01	.5988E-03	.0160	-.3188E 05
840.	-.2080	-.7422E-02	-.2597E-01	.6743E-03	.0169	-.3235E 05
900.	-.2200	-.7854E-02	-.2747E-01	.7544E-03	.0179	-.3277E 05
1200.	-.2920	-.1046E-01	-.3645E-01	.1329E-02	.0238	-.3292E 05
1500.	-.3640	-.1307E-01	-.4544E-01	.2065E-02	.0297	-.3301E 05
1800.	-.4280	-.1541E-01	-.5343E-01	.2855E-02	.0349	-.3369E 05
2400.	-.5080	-.1835E-01	-.6342E-01	.4022E-02	.0414	-.3784E 05
3000.	-.6080	-.2206E-01	-.7591E-01	.5762E-02	.0495	-.3952E 05
4140.	-.6640	-.2415E-01	-.8290E-01	.6872E-02	.0541	-.4994E 05
5400.	-.8880	-.3261E-01	-.1107E 00	.1229E-01	.0723	-.4871E 05
7200.	-1.0800	-.3999E-01	-.1348E 00	.1818E-01	.0880	-.5340E 05
10800.	-1.4400	-.5419E-01	-.1798E 00	.3232E-01	.1173	-.6007E 05
14400.	-1.7200	-.6556E-01	-.2147E 00	.4611E-01	.1401	-.6706E 05
18000.	-2.0320	-.7859E-01	-.2537E 00	.6436E-01	.1655	-.7095E 05
21600.	-2.2600	-.8836E-01	-.2821E 00	.7961E-01	.1841	-.7656E 05
25200.	-2.5120	-.9943E-01	-.3136E 00	.9835E-01	.2046	-.8036E 05
28800.	-2.7480	-.1101E 00	-.3431E 00	.1177E 00	.2239	-.8395E 05
32400.	-2.9560	-.1196E 00	-.3690E 00	.1362E 00	.2408	-.8780E 05
36000.	-3.1480	-.1287E 00	-.3930E 00	.1545E 00	.2564	-.9160E 05
39600.	-3.3480	-.1383E 00	-.4180E 00	.1747E 00	.2727	-.9474E 05
43200.	-3.5360	-.1475E 00	-.4414E 00	.1949E 00	.2880	-.9786E 05
46800.	-3.7240	-.1570E 00	-.4649E 00	.2161E 00	.3034	-.1007E 06
50400.	-3.9000	-.1660E 00	-.4869E 00	.2371E 00	.3177	-.1035E 06
54000.	-4.0900	-.1760E 00	-.5106E 00	.2607E 00	.3332	-.1058E 06
57600.	-4.2600	-.1851E 00	-.5318E 00	.2828E 00	.3470	-.1083E 06
61200.	-4.4440	-.1952E 00	-.5548E 00	.3078E 00	.3620	-.1103E 06
64800.	-4.5840	-.2030E 00	-.5723E 00	.3275E 00	.3734	-.1132E 06
68400.	-4.7320	-.2115E 00	-.5908E 00	.3490E 00	.3855	-.1158E 06

Table CR-5 (Continued)

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
72000.	-4.8720	-.2196E 00	-.6082E 00	.3700E 00	.3969	-.1184E 06
75600.	-5.0120	-.2279E 00	-.6257E 00	.3915E 00	.4083	-.1208E 06
79200.	-5.1520	-.2363E 00	-.6432E 00	.4137E 00	.4197	-.1231E 06
82800.	-5.3280	-.2472E 00	-.6652E 00	.4424E 00	.4340	-.1245E 06
86400.	-5.4680	-.2560E 00	-.6826E 00	.4660E 00	.4454	-.1266E 06
90000.	-5.6200	-.2658E 00	-.7016E 00	.4923E 00	.4578	-.1283E 06
93600.	-5.7400	-.2737E 00	-.7166E 00	.5135E 00	.4676	-.1306E 06
97200.	-5.8680	-.2823E 00	-.7326E 00	.5367E 00	.4780	-.1327E 06
100800.	-5.9760	-.2897E 00	-.7461E 00	.5566E 00	.4868	-.1351E 06
104400.	-6.0680	-.2961E 00	-.7576E 00	.5739E 00	.4943	-.1378E 06
108000.	-6.1880	-.3046E 00	-.7725E 00	.5968E 00	.5041	-.1398E 06
111600.	-6.3080	-.3132E 00	-.7875E 00	.6202E 00	.5138	-.1417E 06
115200.	-6.4200	-.3215E 00	-.8015E 00	.6424E 00	.5230	-.1437E 06
118800.	-6.5080	-.3280E 00	-.8125E 00	.6601E 00	.5301	-.1462E 06
122400.	-6.5880	-.3341E 00	-.8225E 00	.6765E 00	.5367	-.1488E 06
126000.	-6.6680	-.3402E 00	-.8325E 00	.6930E 00	.5432	-.1514E 06
129600.	-6.7880	-.3496E 00	-.8474E 00	.7182E 00	.5529	-.1529E 06
133200.	-6.8760	-.3567E 00	-.8584E 00	.7369E 00	.5601	-.1552E 06
136800.	-6.9640	-.3638E 00	-.8694E 00	.7559E 00	.5673	-.1573E 06
140400.	-7.0600	-.3717E 00	-.8814E 00	.7769E 00	.5751	-.1593E 06
144000.	-7.1480	-.3791E 00	-.8924E 00	.7964E 00	.5823	-.1614E 06
147600.	-7.2280	-.3859E 00	-.9024E 00	.8143E 00	.5888	-.1636E 06
151200.	-7.3080	-.3929E 00	-.9124E 00	.8324E 00	.5953	-.1657E 06
154800.	-7.3680	-.3982E 00	-.9199E 00	.8461E 00	.6002	-.1683E 06
158400.	-7.4480	-.4053E 00	-.9298E 00	.8646E 00	.6067	-.1704E 06
162000.	-7.5200	-.4118E 00	-.9388E 00	.8814E 00	.6126	-.1726E 06
165600.	-7.5880	-.4181E 00	-.9473E 00	.8974E 00	.6181	-.1748E 06
169200.	-7.6720	-.4259E 00	-.9578E 00	.9174E 00	.6250	-.1767E 06
172800.	-7.7520	-.4335E 00	-.9678E 00	.9366E 00	.6315	-.1786E 06
176400.	-7.8320	-.4413E 00	-.9778E 00	.9560E 00	.6380	-.1804E 06
180000.	-7.9320	-.4512E 00	-.9903E 00	.9806E 00	.6461	-.1818E 06
183600.	-7.9880	-.4568E 00	-.9973E 00	.9945E 00	.6507	-.1841E 06
187200.	-8.0680	-.4650E 00	-.1007E 01	.1015E 01	.6572	-.1859E 06
190800.	-8.1480	-.4733E 00	-.1017E 01	.1035E 01	.6637	-.1876E 06
194400.	-8.2360	-.4827E 00	-.1028E 01	.1057E 01	.6709	-.1891E 06
198000.	-8.3000	-.4896E 00	-.1036E 01	.1074E 01	.6761	-.1911E 06
201600.	-8.3720	-.4975E 00	-.1045E 01	.1092E 01	.6820	-.1929E 06
205200.	-8.4280	-.5038E 00	-.1052E 01	.1107E 01	.6865	-.1950E 06
208800.	-8.5080	-.5129E 00	-.1062E 01	.1128E 01	.6931	-.1966E 06
212400.	-8.5680	-.5199E 00	-.1070E 01	.1144E 01	.6979	-.1986E 06

Table CR-5 (Continued)

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
216000.	-8.6360	-.5280E 00	-.1078E 01	.1162E 01	.7035	-.2003E 06
219600.	-8.6840	-.5337E 00	-.1084E 01	.1175E 01	.7074	-.2026E 06
223200.	-8.7560	-.5425E 00	-.1093E 01	.1195E 01	.7133	-.2042E 06
226800.	-8.8280	-.5515E 00	-.1102E 01	.1215E 01	.7191	-.2058E 06
230400.	-8.8760	-.5576E 00	-.1108E 01	.1228E 01	.7230	-.2079E 06
234000.	-8.9200	-.5632E 00	-.1114E 01	.1240E 01	.7266	-.2101E 06
237600.	-8.9880	-.5721E 00	-.1122E 01	.1259E 01	.7322	-.2117E 06
241200.	-9.0520	-.5807E 00	-.1130E 01	.1277E 01	.7374	-.2134E 06
244800.	-9.1000	-.5872E 00	-.1136E 01	.1291E 01	.7413	-.2155E 06
248400.	-9.1400	-.5927E 00	-.1141E 01	.1302E 01	.7445	-.2177E 06
252000.	-9.2040	-.6016E 00	-.1149E 01	.1320E 01	.7498	-.2193E 06
255600.	-9.2680	-.6108E 00	-.1157E 01	.1339E 01	.7550	-.2209E 06
259200.	-9.3160	-.6178E 00	-.1163E 01	.1353E 01	.7589	-.2229E 06
262800.	-9.3800	-.6273E 00	-.1171E 01	.1371E 01	.7641	-.2244E 06
266400.	-9.4360	-.6357E 00	-.1178E 01	.1388E 01	.7687	-.2261E 06
270000.	-9.4780	-.6422E 00	-.1183E 01	.1400E 01	.7721	-.2282E 06
273600.	-9.5280	-.6500E 00	-.1190E 01	.1415E 01	.7761	-.2300E 06
277200.	-9.6280	-.6661E 00	-.1202E 01	.1445E 01	.7843	-.2306E 06
280800.	-9.8040	-.6960E 00	-.1224E 01	.1498E 01	.7986	-.2294E 06
284400.	-9.8920	-.7118E 00	-.1235E 01	.1525E 01	.8058	-.2303E 06
288000.	-9.9560	-.7236E 00	-.1243E 01	.1545E 01	.8110	-.2317E 06
291600.	-10.0280	-.7373E 00	-.1252E 01	.1567E 01	.8169	-.2329E 06
295200.	-10.0760	-.7466E 00	-.1258E 01	.1582E 01	.8208	-.2347E 06
298800.	-10.1000	-.7514E 00	-.1261E 01	.1590E 01	.8227	-.2370E 06
302400.	-10.1480	-.7611E 00	-.1267E 01	.1605E 01	.8267	-.2387E 06
306000.	-10.1840	-.7685E 00	-.1271E 01	.1616E 01	.8296	-.2407E 06
309600.	-10.2600	-.7846E 00	-.1281E 01	.1641E 01	.8358	-.2417E 06
313200.	-10.3160	-.7968E 00	-.1288E 01	.1659E 01	.8403	-.2432E 06
316800.	-10.3640	-.8076E 00	-.1294E 01	.1674E 01	.8442	-.2448E 06
320400.	-10.4160	-.8195E 00	-.1300E 01	.1691E 01	.8485	-.2464E 06
324000.	-10.4560	-.8290E 00	-.1305E 01	.1704E 01	.8517	-.2482E 06
327600.	-10.5040	-.8406E 00	-.1311E 01	.1720E 01	.8557	-.2498E 06
331200.	-10.5480	-.8515E 00	-.1317E 01	.1734E 01	.8592	-.2515E 06
334800.	-10.5840	-.8607E 00	-.1321E 01	.1746E 01	.8622	-.2534E 06
338400.	-10.6280	-.8721E 00	-.1327E 01	.1761E 01	.8658	-.2550E 06
342000.	-10.6680	-.8828E 00	-.1332E 01	.1774E 01	.8690	-.2568E 06
345600.	-10.7080	-.8937E 00	-.1337E 01	.1787E 01	.8723	-.2585E 06
349200.	-10.7760	-.9130E 00	-.1345E 01	.1810E 01	.8778	-.2596E 06
352800.	-10.8200	-.9259E 00	-.1351E 01	.1825E 01	.8814	-.2612E 06
356400.	-10.9000	-.9504E 00	-.1361E 01	.1852E 01	.8879	-.2619E 06

Table CR-5 (Continued)

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
360000.	-10.9560	-.9685E 00	-.1368E 01	.1871E 01	.8925	-.2632E 06
363600.	-11.0260	-.9901E 00	-.1376E 01	.1893E 01	.8977	-.2643E 06
367200.	-11.0600	-.1004E 01	-.1381E 01	.1907E 01	.9009	-.2659E 06
370800.	-11.1080	-.1022E 01	-.1387E 01	.1923E 01	.9049	-.2674E 06
373200.	-11.1560	-.1040E 01	-.1393E 01	.1940E 01	.9088	-.2680E 06
378000.	-11.1880	-.1052E 01	-.1397E 01	.1951E 01	.9114	-.2706E 06
381600.	-11.2280	-.1069E 01	-.1402E 01	.1965E 01	.9146	-.2722E 06
385200.	-11.2520	-.1079E 01	-.1405E 01	.1973E 01	.9165	-.2742E 06
388800.	-11.2600	-.1082E 01	-.1406E 01	.1976E 01	.9172	-.2766E 06
392400.	-11.2760	-.1089E 01	-.1408E 01	.1982E 01	.9185	-.2787E 06
396000.	-11.3000	-.1100E 01	-.1411E 01	.1990E 01	.9205	-.2807E 06
399600.	-11.3240	-.1110E 01	-.1414E 01	.1999E 01	.9225	-.2827E 06
403200.	-11.3440	-.1120E 01	-.1416E 01	.2006E 01	.9241	-.2847E 06
406800.	-11.3720	-.1133E 01	-.1420E 01	.2016E 01	.9264	-.2865E 06
410400.	-11.4200	-.1157E 01	-.1426E 01	.2033E 01	.9303	-.2879E 06
414000.	-11.4280	-.1161E 01	-.1427E 01	.2036E 01	.9309	-.2902E 06
417600.	-11.4680	-.1182E 01	-.1432E 01	.2050E 01	.9342	-.2917E 06
421200.	-11.5000	-.1199E 01	-.1436E 01	.2061E 01	.9368	-.2934E 06
424800.	-11.5360	-.1220E 01	-.1440E 01	.2074E 01	.9397	-.2950E 06
428400.	-11.5720	-.1241E 01	-.1445E 01	.2087E 01	.9427	-.2965E 06
432000.	-11.6280	-.1277E 01	-.1452E 01	.2107E 01	.9472	-.2976E 06
435600.	-11.6760	-.1311E 01	-.1458E 01	.2125E 01	.9511	-.2988E 06
439200.	-11.7360	-.1357E 01	-.1465E 01	.2147E 01	.9560	-.2998E 06
442800.	-11.7720	-.1387E 01	-.1470E 01	.2160E 01	.9589	-.3013E 06
446400.	-11.8120	-.1423E 01	-.1475E 01	.2175E 01	.9622	-.3027E 06
450000.	-11.8520	-.1462E 01	-.1480E 01	.2189E 01	.9655	-.3041E 06
453600.	-11.8760	-.1487E 01	-.1483E 01	.2198E 01	.9674	-.3059E 06
457200.	-11.9080	-.1523E 01	-.1487E 01	.2210E 01	.9700	-.3075E 06
460800.	-11.9080	-.1523E 01	-.1487E 01	.2210E 01	.9700	-.3100E 06
464400.	-11.9480	-.1573E 01	-.1492E 01	.2225E 01	.9733	-.3113E 06
468000.	-11.9840	-.1624E 01	-.1496E 01	.2238E 01	.9762	-.3128E 06
471600.	-11.9960	-.1642E 01	-.1498E 01	.2243E 01	.9772	-.3149E 06
475200.	-12.0080	-.1661E 01	-.1499E 01	.2247E 01	.9782	-.3170E 06
478800.	-12.0320	-.1702E 01	-.1502E 01	.2256E 01	.9801	-.3187E 06
482400.	-12.0400	-.1716E 01	-.1503E 01	.2259E 01	.9808	-.3209E 06
486000.	-12.0520	-.1739E 01	-.1505E 01	.2264E 01	.9818	-.3230E 06
489600.	-12.0680	-.1771E 01	-.1507E 01	.2270E 01	.9831	-.3250E 06
493200.	-12.0880	-.1815E 01	-.1509E 01	.2277E 01	.9847	-.3268E 06
496800.	-12.1080	-.1864E 01	-.1512E 01	.2285E 01	.9863	-.3287E 06
500400.	-12.1280	-.1919E 01	-.1514E 01	.2293E 01	.9879	-.3305E 06

CR-5 (Continued)

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
504000.	-12.1480	-.1982E 01	-.1517E 01	.2300E 01	.9896	-.3323E 06
507600.	-12.1720	-.2072E 01	-.1520E 01	.2309E 01	.9915	-.3340E 06
511200.	-12.1960	-.2186E 01	-.1523E 01	.2318E 01	.9935	-.3357E 06
514800.	-12.2200	-.2341E 01	-.1526E 01	.2327E 01	.9954	-.3374E 06
518400.	-12.2440	-.2584E 01	-.1529E 01	.2337E 01	.9974	-.3391E 06

Table CR-6. Weight Losses for 1.67:1.00 Mole Ratio Cr_2O_3-Nb_2O_5 Between the Oxygen Partial Pressure Range of 4.70×10^{-14} to 1.33×10^{-16} atm. at 1000°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	-.0240	-.4784E-03	-.2996E-02	.8978E-05	.0011	-.2002E 05
120.	-.0320	-.6380E-03	-.3995E-02	.1596E-04	.0015	-.3004E 05
180.	-.0200	-.3986E-03	-.2497E-02	.6234E-05	.0009	-.7209E 05
240.	-.0200	-.3986E-03	-.2497E-02	.6234E-05	.0009	-.9612E 05
300.	-.0120	-.2391E-03	-.1498E-02	.2244E-05	.0006	-.2002E 06
360.	-.0480	-.9573E-03	-.5993E-02	.3591E-04	.0022	-.6007E 05
420.	.0440	.8757E-03	.5493E-02	.3017E-04	-.0020	.7646E 05
480.	.0280	.5575E-03	.3496E-02	.1222E-04	-.0013	.1373E 06
540.	-.0040	-.7969E-04	-.4994E-03	.2494E-06	.0002	-.1081E 07
600.	-.0200	-.3986E-03	-.2497E-02	.6234E-05	.0009	-.2403E 06
660.	-.0360	-.7178E-03	-.4494E-02	.2020E-04	.0017	-.1468E 06
720.	-.0600	-.1197E-02	-.7491E-02	.5611E-04	.0028	-.9612E 05
780.	-.0760	-.1517E-02	-.9488E-02	.9002E-04	.0035	-.8221E 05
840.	-.1080	-.2157E-02	-.1348E-01	.1818E-03	.0050	-.6230E 05
900.	-.1320	-.2638E-02	-.1648E-01	.2716E-03	.0061	-.5461E 05
1200.	-.1480	-.2958E-02	-.1848E-01	.3414E-03	.0068	-.6495E 05
1500.	-.1720	-.3440E-02	-.2147E-01	.4611E-03	.0079	-.6985E 05
1800.	-.1880	-.3762E-02	-.2347E-01	.5509E-03	.0086	-.7569E 05
2400.	-.2300	-.4606E-02	-.2871E-01	.8245E-03	.0106	-.8358E 05
3000.	-.2400	-.4808E-02	-.2996E-01	.8978E-03	.0110	-.1001E 06
4140.	-.2640	-.5291E-02	-.3296E-01	.1086E-02	.0121	-.1256E 06
5400.	-.3840	-.7718E-02	-.4794E-01	.2298E-02	.0176	-.1126E 06
7200.	-.4840	-.9751E-02	-.6042E-01	.3651E-02	.0222	-.1192E 06
10800.	-.5680	-.1147E-01	-.7091E-01	.5028E-02	.0261	-.1523E 06
14400.	-.7280	-.1475E-01	-.9089E-01	.8260E-02	.0334	-.1584E 06
18000.	-.8960	-.1823E-01	-.1119E 00	.1251E-01	.0411	-.1609E 06
21600.	-1.0360	-.2115E-01	-.1293E 00	.1673E-01	.0475	-.1670E 06
25200.	-1.3480	-.2772E-01	-.1683E 00	.2832E-01	.0618	-.1497E 06
28800.	-1.6800	-.3483E-01	-.2097E 00	.4399E-01	.0771	-.1373E 06
32400.	-2.2560	-.4744E-01	-.2816E 00	.7933E-01	.1035	-.1150E 06
36000.	-2.7560	-.5870E-01	-.3441E 00	.1184E 00	.1264	-.1046E 06
39600.	-3.1960	-.6885E-01	-.3990E 00	.1592E 00	.1466	-.9925E 05
43200.	-3.6120	-.7867E-01	-.4509E 00	.2033E 00	.1657	-.9580E 05
46800.	-4.0040	-.8813E-01	-.4999E 00	.2499E 00	.1837	-.9362E 05
50400.	-4.4680	-.9961E-01	-.5578E 00	.3111E 00	.2050	-.9035E 05
54000.	-4.8160	-.1084E 00	-.6012E 00	.3615E 00	.2209	-.8981E 05
57600.	-5.2060	-.1185E 00	-.6499E 00	.4224E 00	.2388	-.8862E 05
61200.	-5.5560	-.1278E 00	-.6936E 00	.4811E 00	.2549	-.8823E 05
64800.	-5.9860	-.1394E 00	-.7473E 00	.5585E 00	.2746	-.8672E 05
68400.	-6.3360	-.1491E 00	-.7910E 00	.6257E 00	.2906	-.8647E 05

Table CR-6 (Continued

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
72000.	-6.6760	-.1588E 00	-.8335E 00	.6947E 00	.3062	-.8639E 05
75600.	-7.0360	-.1693E 00	-.8784E 00	.7716E 00	.3228	-.8607E 05
79200.	-7.3760	-.1794E 00	-.9208E 00	.8480E 00	.3383	-.8601E 05
82800.	-7.7160	-.1897E 00	-.9633E 00	.9279E 00	.3539	-.8595E 05
86400.	-8.0360	-.1997E 00	-.1003E 01	.1007E 01	.3686	-.8612E 05
90000.	-8.3360	-.2093E 00	-.1041E 01	.1083E 01	.3824	-.8648E 05
93600.	-8.6860	-.2207E 00	-.1084E 01	.1176E 01	.3984	-.8632E 05
97200.	-8.9860	-.2308E 00	-.1122E 01	.1259E 01	.4122	-.8664E 05
100800.	-9.2860	-.2411E 00	-.1159E 01	.1344E 01	.4260	-.8695E 05
104400.	-9.5660	-.2509E 00	-.1194E 01	.1426E 01	.4388	-.8742E 05
108000.	-9.9200	-.2636E 00	-.1238E 01	.1534E 01	.4550	-.8721E 05
111600.	-10.1960	-.2738E 00	-.1273E 01	.1620E 01	.4677	-.8767E 05
115200.	-10.4360	-.2829E 00	-.1303E 01	.1697E 01	.4787	-.8842E 05
118800.	-10.6640	-.2917E 00	-.1331E 01	.1772E 01	.4892	-.8923E 05
122400.	-10.8080	-.2974E 00	-.1349E 01	.1821E 01	.4958	-.9071E 05
126000.	-11.1360	-.3105E 00	-.1390E 01	.1933E 01	.5108	-.9063E 05
129600.	-11.3640	-.3199E 00	-.1419E 01	.2013E 01	.5213	-.9135E 05
133200.	-11.6580	-.3323E 00	-.1455E 01	.2118E 01	.5348	-.9152E 05
136800.	-11.8760	-.3418E 00	-.1483E 01	.2198E 01	.5448	-.9227E 05
140400.	-12.0760	-.3506E 00	-.1508E 01	.2273E 01	.5539	-.9313E 05
144000.	-12.2760	-.3596E 00	-.1533E 01	.2349E 01	.5631	-.9396E 05
147600.	-12.4840	-.3692E 00	-.1559E 01	.2429E 01	.5727	-.9470E 05
151200.	-12.6840	-.3787E 00	-.1584E 01	.2508E 01	.5818	-.9548E 05
154800.	-12.8900	-.3886E 00	-.1609E 01	.2590E 01	.5913	-.9619E 05
158400.	-13.0840	-.3981E 00	-.1633E 01	.2668E 01	.6002	-.9697E 05
162000.	-13.3180	-.4100E 00	-.1663E 01	.2764E 01	.6109	-.9743E 05
165600.	-13.5040	-.4196E 00	-.1686E 01	.2842E 01	.6194	-.9823E 05
169200.	-13.6760	-.4287E 00	-.1707E 01	.2915E 01	.6273	-.9910E 05
172800.	-13.8720	-.4393E 00	-.1732E 01	.2999E 01	.6363	-.9978E 05
176400.	-14.0360	-.4484E 00	-.1752E 01	.3071E 01	.6439	-.1007E 06
180000.	-14.2280	-.4592E 00	-.1776E 01	.3155E 01	.6527	-.1013E 06
183600.	-14.3880	-.4685E 00	-.1796E 01	.3227E 01	.6600	-.1022E 06
187200.	-14.5640	-.4790E 00	-.1818E 01	.3306E 01	.6681	-.1030E 06
190800.	-14.7480	-.4901E 00	-.1841E 01	.3390E 01	.6765	-.1036E 06
194400.	-14.8560	-.4968E 00	-.1855E 01	.3440E 01	.6815	-.1048E 06
198000.	-15.0960	-.5121E 00	-.1885E 01	.3552E 01	.6925	-.1051E 06
201600.	-15.2560	-.5226E 00	-.1905E 01	.3628E 01	.6998	-.1058E 06
205200.	-15.4120	-.5331E 00	-.1924E 01	.3702E 01	.7070	-.1066E 06
208800.	-15.5880	-.5452E 00	-.1946E 01	.3787E 01	.7150	-.1073E 06
212400.	-15.7480	-.5566E 00	-.1966E 01	.3865E 01	.7224	-.1080E 06

Table CR-6 (Continued

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
216000.	-15.9040	-.5679E 00	-.1986E 01	.3942E 01	.7295	-.1088E 06
219600.	-16.0720	-.5805E 00	-.2006E 01	.4026E 01	.7372	-.1094E 06
223200.	-16.2760	-.5962E 00	-.2032E 01	.4129E 01	.7466	-.1098E 06
226800.	-16.4120	-.6070E 00	-.2049E 01	.4198E 01	.7528	-.1107E 06
230400.	-16.5600	-.6191E 00	-.2067E 01	.4274E 01	.7596	-.1114E 06
234000.	-16.6960	-.6305E 00	-.2084E 01	.4345E 01	.7659	-.1123E 06
237600.	-16.8360	-.6426E 00	-.2102E 01	.4418E 01	.7723	-.1130E 06
241200.	-16.9680	-.6543E 00	-.2118E 01	.4487E 01	.7783	-.1139E 06
244800.	-17.1240	-.6686E 00	-.2138E 01	.4570E 01	.7855	-.1145E 06
248400.	-17.2600	-.6814E 00	-.2155E 01	.4643E 01	.7917	-.1153E 06
252000.	-17.4200	-.6970E 00	-.2175E 01	.4730E 01	.7991	-.1159E 06
255600.	-17.5640	-.7115E 00	-.2193E 01	.4808E 01	.8057	-.1166E 06
259200.	-17.7000	-.7257E 00	-.2210E 01	.4883E 01	.8119	-.1173E 06
262800.	-17.8160	-.7381E 00	-.2224E 01	.4947E 01	.8172	-.1182E 06
266400.	-17.9560	-.7537E 00	-.2242E 01	.5025E 01	.8237	-.1188E 06
270000.	-18.0920	-.7693E 00	-.2259E 01	.5102E 01	.8299	-.1195E 06
273600.	-18.2120	-.7836E 00	-.2274E 01	.5170E 01	.8354	-.1203E 06
277200.	-18.3560	-.8014E 00	-.2292E 01	.5252E 01	.8420	-.1210E 06
280800.	-18.4680	-.8158E 00	-.2306E 01	.5316E 01	.8472	-.1218E 06
284400.	-18.5920	-.8322E 00	-.2321E 01	.5387E 01	.8528	-.1225E 06
288000.	-18.7160	-.8493E 00	-.2337E 01	.5460E 01	.8585	-.1233E 06
291600.	-18.8360	-.8666E 00	-.2352E 01	.5530E 01	.8640	-.1240E 06
295200.	-18.9520	-.8839E 00	-.2366E 01	.5598E 01	.8694	-.1248E 06
298800.	-19.0600	-.9007E 00	-.2380E 01	.5662E 01	.8743	-.1256E 06
302400.	-19.1640	-.9[illegible]75E 00	-.2393E 01	.5724E 01	.8791	-.1264E 06
306000.	-19.2840	-.9377E 00	-.2407E 01	.5796E 01	.8846	-.1271E 06
309600.	-19.4040	-.9590E 00	-.2422E 01	.5868E 01	.8901	-.1278E 06
313200.	-19.5000	-.9767E 00	-.2434E 01	.5927E 01	.8945	-.1287E 06
316800.	-19.6080	-.9976E 00	-.2448E 01	.5992E 01	.8994	-.1294E 06
320400.	-19.7320	-.1023E 01	-.2463E 01	.6068E 01	.9051	-.1301E 06
324000.	-19.8120	-.1040E 01	-.2473E 01	.6118E 01	.9088	-.1310E 06
327600.	-19.8080	-.1039E 01	-.2473E 01	.6115E 01	.9086	-.1325E 06
331200.	-19.9960	-.1082E 01	-.2496E 01	.6232E 01	.9172	-.1327E 06
334800.	-20.1120	-.1111E 01	-.2511E 01	.6304E 01	.9226	-.1333E 06
338400.	-20.2320	-.1143E 01	-.2526E 01	.6380E 01	.9281	-.1340E 06
342000.	-20.3240	-.1169E 01	-.2537E 01	.6438E 01	.9323	-.1346E 06
345600.	-20.4360	-.1204E 01	-.2551E 01	.6509E 01	.9374	-.1355E 06
349200.	-20.5480	-.1241E 01	-.2565E 01	.6581E 01	.9426	-.1361E 06
352800.	-20.6440	-.1275E 01	-.2577E 01	.6642E 01	.9470	-.1369E 06
356400.	-20.7400	-.1313E 01	-.2589E 01	.6704E 01	.9514	-.1376E 06

Table CR-6 (Continued)

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQP	M(T)/Q	TIME/M(T)/A
360000.	-20.8360	-.1354E 01	-.2601E 01	.6766E 01	.9558	-.1384E 06
363600.	-20.9240	-.1396E 01	-.2612E 01	.6824E 01	.9598	-.1392E 06
367200.	-21.0360	-.1455E 01	-.2626E 01	.6897E 01	.9650	-.1398E 06
370800.	-21.1320	-.1514E 01	-.2638E 01	.6960E 01	.9694	-.1406E 06
373200.	-21.2200	-.1575E 01	-.2649E 01	.7018E 01	.9734	-.1409E 06
378000.	-21.2860	-.1627E 01	-.2657E 01	.7062E 01	.9764	-.1422E 06

Table CR-7. Weight Losses for 1.67:1.00 Mole Ratio Cr_2O_3-Nb_2O_5 Between the Oxygen Partial Pressure Range of 3.4×10^{-2} to 7.017×10^{-9} atm. at 1175°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	-.0120	-.1102E-02	-.1498E-02	.2244E-05	.0025	-.4005E 05
120.	-.0280	-.2575E-02	-.3496E-02	.1222E-04	.0059	-.3433E 05
180.	-.0960	-.8894E-02	-.1199E-01	.1436E-03	.0203	-.1502E 05
240.	-.1400	-.1303E-01	-.1748E-01	.3055E-03	.0296	-.1373E 05
300.	-.1720	-.1607E-01	-.2147E-01	.4611E-03	.0363	-.1397E 05
360.	-.2120	-.1989E-01	-.2647E-01	.7005E-03	.0448	-.1360E 05
420.	-.2480	-.2336E-01	-.3096E-01	.9586E-03	.0524	-.1357E 05
480.	-.2880	-.2725E-01	-.3596E-01	.1293E-02	.0608	-.1335E 05
540.	-.3200	-.3038E-01	-.3995E-01	.1596E-02	.0676	-.1352E 05
600.	-.3640	-.3473E-01	-.4544E-01	.2065E-02	.0769	-.1320E 05
660.	-.4040	-.3872E-01	-.5044E-01	.2544E-02	.0853	-.1309E 05
720.	-.4380	-.4215E-01	-.5468E-01	.2990E-02	.0925	-.1317E 05
780.	-.4800	-.4641E-01	-.5993E-01	.3591E-02	.1014	-.1302E 05
840.	-.5080	-.4928E-01	-.6342E-01	.4022E-02	.1073	-.1324E 05
900.	-.5480	-.5341E-01	-.6841E-01	.4681E-02	.1157	-.1316E 05
1200.	-.6680	-.6603E-01	-.8340E-01	.6955E-02	.1410	-.1439E 05
1500.	-.7560	-.7553E-01	-.9438E-01	.8908E-02	.1596	-.1589E 05
1800.	-.8860	-.8995E-01	-.1106E 00	.1223E-01	.1871	-.1627E 05
2400.	-1.0280	-.1063E 00	-.1283E 00	.1647E-01	.2171	-.1870E 05
3000.	-1.1400	-.1196E 00	-.1423E 00	.2026E-01	.2407	-.2108E 05
4140.	-1.2680	-.1353E 00	-.1583E 00	.2506E-01	.2677	-.2615E 05
5400.	-1.5720	-.1752E 00	-.1963E 00	.3852E-01	.3319	-.2752E 05
7200.	-1.7900	-.2062E 00	-.2235E 00	.4994E-01	.3780	-.3222E 05
10800.	-2.1640	-.2651E 00	-.2702E 00	.7299E-01	.4569	-.3998E 05
14400.	-2.4680	-.3198E 00	-.3081E 00	.9493E-01	.5211	-.4674E 05
18000.	-2.7080	-.3683E 00	-.3381E 00	.1143E 00	.5718	-.5324E 05
21600.	-2.9320	-.4192E 00	-.3660E 00	.1340E 00	.6191	-.5901E 05
25200.	-3.1080	-.4638E 00	-.3880E 00	.1506E 00	.6562	-.6495E 05
28800.	-3.2520	-.5040E 00	-.4060E 00	.1648E 00	.6867	-.7094E 05
32400.	-3.3800	-.5432E 00	-.4220E 00	.1781E 00	.7137	-.7678E 05
36000.	-3.5120	-.5876E 00	-.4385E 00	.1922E 00	.7416	-.8211E 05
39600.	-3.6040	-.6216E 00	-.4499E 00	.2024E 00	.7610	-.8801E 05
43200.	-3.6920	-.6567E 00	-.4609E 00	.2125E 00	.7796	-.9372E 05
46800.	-3.7480	-.6807E 00	-.4679E 00	.2189E 00	.7914	-.1000E 06
50400.	-3.8200	-.7135E 00	-.4769E 00	.2274E 00	.8066	-.1057E 06
54000.	-3.8760	-.7409E 00	-.4839E 00	.2342E 00	.8184	-.1116E 06
57600.	-3.9400	-.7745E 00	-.4919E 00	.2420E 00	.8319	-.1171E 06
61200.	-4.0120	-.8157E 00	-.5009E 00	.2509E 00	.8471	-.1222E 06
64800.	-4.0520	-.8404E 00	-.5059E 00	.2559E 00	.8556	-.1281E 06
68400.	-4.1360	-.8973E 00	-.5164E 00	.2666E 00	.8733	-.1325E 06

Table CR-7 (Continued)

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
72000.	-4.1800	-.9303E 00	-.5218E 00	.2723E 00	.8826	-.1380E 06
75600.	-4.2040	-.9495E 00	-.5248E 00	.2755E 00	.8877	-.1440E 06
79200.	-4.2120	-.9561E 00	-.5258E 00	.2765E 00	.8894	-.1506E 06
82800.	-4.2520	-.9906E 00	-.5308E 00	.2818E 00	.8978	-.1560E 06
86400.	-4.2520	-.9906E 00	-.5308E 00	.2818E 00	.8978	-.1628E 06
90000.	-4.2920	-.1028E 01	-.5358E 00	.2871E 00	.9062	-.1680E 06
93600.	-4.3070	-.1043E 01	-.5377E 00	.2891E 00	.9094	-.1741E 06
97200.	-4.4320	-.1193E 01	-.5533E 00	.3062E 00	.9358	-.1757E 06
100800.	-4.4720	-.1254E 01	-.5583E 00	.3117E 00	.9443	-.1805E 06
104400.	-4.4920	-.1288E 01	-.5608E 00	.3145E 00	.9485	-.1862E 06
108000.	-4.5240	-.1349E 01	-.5648E 00	.3190E 00	.9552	-.1912E 06
111600.	-4.5480	-.1401E 01	-.5678E 00	.3224E 00	.9603	-.1966E 06
115200.	-4.5680	-.1450E 01	-.5703E 00	.3252E 00	.9645	-.2020E 06
118800.	-4.5800	-.1482E 01	-.5718E 00	.3269E 00	.9671	-.2078E 06
122400.	-4.5880	-.1505E 01	-.5728E 00	.3281E 00	.9688	-.2137E 06
126000.	-4.6360	-.1675E 01	-.5788E 00	.3350E 00	.9789	-.2177E 06
129600.	-4.6520	-.1751E 01	-.5808E 00	.3373E 00	.9823	-.2232E 06
133200.	-4.6520	-.1751E 01	-.5808E 00	.3373E 00	.9823	-.2293E 06
136800.	-4.6520	-.1751E 01	-.5808E 00	.3373E 00	.9823	-.2355E 06
140400.	-4.6720	-.1869E 01	-.5833E 00	.3402E 00	.9865	-.2407E 06
144000.	-4.6920	-.2032E 01	-.5858E 00	.3431E 00	.9907	-.2458E 06
147600.	-4.6920	-.2032E 01	-.5858E 00	.3431E 00	.9907	-.2520E 06
151200.	-4.6920	-.2032E 01	-.5858E 00	.3431E 00	.9907	-.2561E 06
154800.	-4.6960	-.2073E 01	-.5863E 00	.3437E 00	.9916	-.2640E 06
158400.	-4.7320	-.3073E 01	-.5908E 00	.3490E 00	.9992	-.2681E 06

Table CR-8. Weight Losses for 1.67:1.00 Mole Ratio Cr_2O_3-Nb_2O_5 Between the Oxygen Partial Pressure Range of 7.017×10^{-9} to 2.52×10^{-11} atm. at 1175°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	-.0720	-.1974E-02	-.8989E-02	.8080E-04	.0045	-.6675E 04
120.	-.1080	-.2964E-02	-.1348E-01	.1818E-03	.0068	-.8900E 04
180.	-.1440	-.3956E-02	-.1798E-01	.3232E-03	.0091	-.1001E 05
240.	-.1880	-.5172E-02	-.2347E-01	.5509E-03	.0118	-.1023E 05
300.	-.2360	-.6503E-02	-.2946E-01	.8681E-03	.0149	-.1018E 05
360.	-.3000	-.8263E-02	-.3745E-01	.1403E-02	.0189	-.9612E 04
420.	-.3600	-.9959E-02	-.4494E-01	.2020E-02	.0227	-.9345E 04
480.	-.4040	-.1119E-01	-.5044E-01	.2544E-02	.0254	-.9517E 04
540.	-.4320	-.1198E-01	-.5393E-01	.2909E-02	.0272	-.1001E 05
600.	-.4640	-.1288E-01	-.5793E-01	.3356E-02	.0292	-.1036E 05
660.	-.5000	-.1389E-01	-.6242E-01	.3897E-02	.0315	-.1057E 05
720.	-.5360	-.1491E-01	-.6692E-01	.4478E-02	.0338	-.1076E 05
780.	-.5760	-.1605E-01	-.7191E-01	.5171E-02	.0363	-.1085E 05
840.	-.6320	-.1764E-01	-.7890E-01	.6225E-02	.0398	-.1065E 05
900.	-.6680	-.1866E-01	-.8340E-01	.6955E-02	.0421	-.1079E 05
1200.	-.8520	-.2395E-01	-.1064E 00	.1131E-01	.0537	-.1128E 05
1500.	-1.0200	-.2883E-01	-.1273E 00	.1622E-01	.0642	-.1178E 05
1800.	-1.1720	-.3330E-01	-.1463E 00	.2141E-01	.0738	-.1230E 05
2400.	-1.4640	-.4201E-01	-.1828E 00	.3341E-01	.0922	-.1313E 05
3000.	-1.7080	-.4942E-01	-.2132E 00	.4547E-01	.1076	-.1407E 05
4140.	-1.9440	-.5671E-01	-.2427E 00	.5890E-01	.1224	-.1706E 05
5400.	-2.5840	-.7713E-01	-.3226E 00	.1041E 00	.1627	-.1674E 05
7200.	-3.1120	-.9473E-01	-.3885E 00	.1509E 00	.1960	-.1853E 05
10800.	-4.0280	-.1271E 00	-.5029E 00	.2529E 00	.2537	-.2148E 05
14400.	-4.7840	-.1557E 00	-.5973E 00	.3567E 00	.3013	-.2411E 05
18000.	-5.4400	-.1821E 00	-.6792E 00	.4612E 00	.3426	-.2650E 05
21600.	-6.0400	-.2079E 00	-.7541E 00	.5686E 00	.3804	-.2865E 05
25200.	-6.5920	-.2329E 00	-.8230E 00	.6773E 00	.4151	-.3062E 05
28800.	-7.0480	-.2548E 00	-.8799E 00	.7742E 00	.4438	-.3273E 05
32400.	-7.4700	-.2761E 00	-.9326E 00	.8697E 00	.4704	-.3474E 05
36000.	-7.8680	-.2971E 00	-.9823E 00	.9649E 00	.4955	-.3665E 05
39600.	-8.2600	-.3189E 00	-.1031E 01	.1063E 01	.5202	-.3840E 05
43200.	-8.6040	-.3390E 00	-.1074E 01	.1154E 01	.5418	-.4022E 05
46800.	-8.9120	-.3577E 00	-.1113E 01	.1238E 01	.5612	-.4206E 05
50400.	-9.2280	-.3779E 00	-.1152E 01	.1327E 01	.5811	-.4375E 05
54000.	-9.5040	-.3963E 00	-.1187E 01	.1408E 01	.5985	-.4551E 05
57600.	-9.7760	-.4152E 00	-.1220E 01	.1490E 01	.6156	-.4719E 05
61200.	-9.9960	-.4312E 00	-.1248E 01	.1557E 01	.6295	-.4904E 05
64800.	-10.2560	-.4508E 00	-.1280E 01	.1639E 01	.6458	-.5061E 05
68400.	-10.4560	-.4665E 00	-.1305E 01	.1704E 01	.6584	-.5240E 05

Table CR-8 (Continued)

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
72000.	-10.6360	-.4812E 00	-.1328E 01	.1763E 01	.6698	-.5422E 05
75600.	-10.8260	-.4972E 00	-.1352E 01	.1827E 01	.6817	-.5594E 05
79200.	-11.0250	-.5147E 00	-.1376E 01	.1894E 01	.6943	-.5754E 05
82800.	-11.2060	-.5312E 00	-.1399E 01	.1957E 01	.7057	-.5919E 05
86400.	-11.3560	-.5453E 00	-.1418E 01	.2010E 01	.7151	-.6094E 05
90000.	-11.5160	-.5610E 00	-.1438E 01	.2067E 01	.7252	-.6260E 05
93600.	-11.6760	-.5772E 00	-.1458E 01	.2125E 01	.7353	-.6421E 05
97200.	-11.7760	-.5876E 00	-.1470E 01	.2161E 01	.7416	-.6612E 05
100800.	-11.9060	-.6016E 00	-.1486E 01	.2209E 01	.7497	-.6782E 05
104400.	-12.0760	-.6206E 00	-.1508E 01	.2273E 01	.7605	-.6925E 05
108000.	-12.1760	-.6322E 00	-.1520E 01	.2311E 01	.7668	-.7105E 05
111600.	-12.2760	-.6441E 00	-.1533E 01	.2349E 01	.7730	-.7282E 05
115200.	-12.4060	-.6600E 00	-.1549E 01	.2399E 01	.7812	-.7438E 05
118800.	-12.4960	-.6714E 00	-.1560E 01	.2434E 01	.7869	-.7615E 05
122400.	-12.6360	-.6898E 00	-.1578E 01	.2489E 01	.7957	-.7759E 05
126000.	-12.7160	-.7006E 00	-.1588E 01	.2520E 01	.8008	-.7937E 05
129600.	-12.8360	-.7174E 00	-.1602E 01	.2568E 01	.8083	-.8087E 05
133200.	-12.9260	-.7304E 00	-.1614E 01	.2604E 01	.8140	-.8254E 05
136800.	-12.9960	-.7409E 00	-.1622E 01	.2632E 01	.8184	-.8432E 05
140400.	-13.0960	-.7562E 00	-.1635E 01	.2673E 01	.8247	-.8587E 05
144000.	-13.0960	-.7562E 00	-.1635E 01	.2673E 01	.8247	-.8808E 05
147600.	-13.0960	-.7562E 00	-.1635E 01	.2673E 01	.8247	-.9028E 05
151200.	-13.0960	-.7562E 00	-.1635E 01	.2673E 01	.8247	-.9248E 05
154800.	-13.0960	-.7562E 00	-.1635E 01	.2673E 01	.8247	-.9468E 05
158400.	-13.0960	-.7562E 00	-.1635E 01	.2673E 01	.8247	-.9688E 05
162000.	-13.0960	-.7562E 00	-.1635E 01	.2673E 01	.8247	-.9909E 05
165600.	-13.1440	-.7637E 00	-.1641E 01	.2693E 01	.8277	-.1009E 06
169200.	-13.1440	-.7637E 00	-.1641E 01	.2693E 01	.8277	-.1031E 06
172800.	-13.1440	-.7637E 00	-.1641E 01	.2693E 01	.8277	-.1053E 06
176400.	-13.1440	-.7637E 00	-.1641E 01	.2693E 01	.8277	-.1075E 06
180000.	-13.1440	-.7637E 00	-.1641E 01	.2693E 01	.8277	-.1097E 06
183600.	-13.1440	-.7637E 00	-.1641E 01	.2693E 01	.8277	-.1119E 06
187200.	-13.1940	-.7717E 00	-.1647E 01	.2713E 01	.8309	-.1136E 06
190800.	-13.1940	-.7717E 00	-.1647E 01	.2713E 01	.8309	-.1158E 06
194400.	-13.1940	-.7717E 00	-.1647E 01	.2713E 01	.8309	-.1180E 06
198000.	-13.1940	-.7717E 00	-.1647E 01	.2713E 01	.8309	-.1202E 06
201600.	-13.1940	-.7717E 00	-.1647E 01	.2713E 01	.8309	-.1224E 06
205200.	-13.1950	-.7719E 00	-.1647E 01	.2714E 01	.8309	-.1246E 06
208800.	-13.2440	-.7799E 00	-.1653E 01	.2734E 01	.8340	-.1263E 06
212400.	-13.2440	-.7799E 00	-.1653E 01	.2734E 01	.8340	-.1285E 06

Table CR-8 (Continued)

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
216000.	-13.2440	-.7799E 00	-.1653E 01	.2734E 01	.8340	-.1306E 05
219600.	-13.2440	-.7799E 00	-.1653E 01	.2734E 01	.8340	-.1328E 06
223200.	-13.2440	-.7799E 00	-.1653E 01	.2734E 01	.8340	-.1350E 06
226800.	-13.2440	-.7799E 00	-.1653E 01	.2734E 01	.8340	-.1372E 06
230400.	-14.0440	-.9370E 00	-.1753E 01	.3074E 01	.8844	-.1314E 06
234000.	-14.0440	-.9370E 00	-.1753E 01	.3074E 01	.8844	-.1335E 06
237600.	-14.0440	-.9370E 00	-.1753E 01	.3074E 01	.8844	-.1355E 06
241200.	-14.0440	-.9370E 00	-.1753E 01	.3074E 01	.8844	-.1376E 06
244800.	-14.0440	-.9370E 00	-.1753E 01	.3074E 01	.8844	-.1396E 06
248400.	-14.0440	-.9370E 00	-.1753E 01	.3074E 01	.8844	-.1417E 06
252000.	-14.9720	-.1243E 01	-.1869E 01	.3494E 01	.9428	-.1348E 06
255600.	-15.0160	-.1264E 01	-.1875E 01	.3514E 01	.9456	-.1363E 06
259200.	-15.0560	-.1285E 01	-.1880E 01	.3533E 01	.9481	-.1379E 06
262800.	-15.1080	-.1313E 01	-.1886E 01	.3558E 01	.9514	-.1393E 06
266400.	-15.1560	-.1341E 01	-.1892E 01	.3580E 01	.9544	-.1408E 06
270000.	-15.1960	-.1366E 01	-.1897E 01	.3599E 01	.9569	-.1423E 06
273600.	-15.2160	-.1379E 01	-.1900E 01	.3609E 01	.9582	-.1440E 06
277200.	-15.2760	-.1420E 01	-.1907E 01	.3637E 01	.9620	-.1454E 06
280800.	-15.3160	-.1450E 01	-.1912E 01	.3656E 01	.9645	-.1469E 06
284400.	-15.3560	-.1482E 01	-.1917E 01	.3675E 01	.9670	-.1483E 06
288000.	-15.3960	-.1516E 01	-.1922E 01	.3694E 01	.9695	-.1498E 06
291600.	-15.4600	-.1578E 01	-.1930E 01	.3725E 01	.9736	-.1511E 06
295200.	-15.4840	-.1603E 01	-.1933E 01	.3737E 01	.9751	-.1527E 06
298800.	-15.5240	-.1649E 01	-.1938E 01	.3756E 01	.9776	-.1542E 06
302400.	-15.5800	-.1724E 01	-.1945E 01	.3783E 01	.9811	-.1555E 06
306000.	-15.5960	-.1748E 01	-.1947E 01	.3791E 01	.9821	-.1572E 06
309600.	-15.6360	-.1813E 01	-.1952E 01	.3811E 01	.9846	-.1586E 06
313200.	-15.6760	-.1891E 01	-.1957E 01	.3830E 01	.9872	-.1600E 06
316800.	-15.7160	-.1986E 01	-.1962E 01	.3850E 01	.9897	-.1615E 06
320400.	-15.7320	-.2031E 01	-.1964E 01	.3857E 01	.9907	-.1631E 06
324000.	-15.7560	-.2107E 01	-.1967E 01	.3869E 01	.9922	-.1647E 06
327600.	-15.7880	-.2237E 01	-.1971E 01	.3885E 01	.9942	-.1662E 06
331200.	-15.8040	-.2320E 01	-.1973E 01	.3893E 01	.9952	-.1679E 06
334800.	-15.8400	-.2599E 01	-.1978E 01	.3911E 01	.9975	-.1693E 06
338400.	-15.8600	-.2900E 01	-.1980E 01	.3920E 01	.9987	-.1709E 06
342000.	-15.8760	-.3599E 01	-.1982E 01	.3928E 01	.9997	-.1726E 06

Table CR-9. Weight Losses for 1.67:1.00 Mole Ratio Cr_2O_3-Nb_2O_5 Between the Oxygen Partial Pressure Range of 2.52×10^{-11} to 1.46×10^{-13} atm. at 1175°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	.0000	.0000E 00	.0000E 00	.0000E 00	.0000	.6000E 02
120.	-.0200	-.1983E-03	-.2497E-02	.6234E-05	.0005	-.4806E 05
180.	-.0640	-.6349E-03	-.7990E-02	.6384E-04	.0015	-.2253E 05
240.	-.1080	-.1072E-02	-.1348E-01	.1818E-03	.0025	-.1780E 05
300.	-.1680	-.1669E-02	-.2097E-01	.4399E-03	.0038	-.1430E 05
360.	-.2840	-.2824E-02	-.3546E-01	.1257E-02	.0065	-.1015E 05
420.	-.3480	-.3463E-02	-.4345E-01	.1888E-02	.0079	-.9667E 04
480.	-.4240	-.4223E-02	-.5293E-01	.2802E-02	.0097	-.9068E 04
540.	-.5000	-.4985E-02	-.6242E-01	.3897E-02	.0114	-.8651E 04
600.	-.6200	-.6190E-02	-.7740E-01	.5991E-02	.0142	-.7752E 04
660.	-.7200	-.7196E-02	-.8989E-01	.8080E-02	.0164	-.7342E 04
720.	-.8120	-.8125E-02	-.1014E 00	.1028E-01	.0185	-.7102E 04
780.	-.8960	-.8974E-02	-.1119E 00	.1251E-01	.0205	-.6973E 04
840.	-.9720	-.9744E-02	-.1213E 00	.1473E-01	.0222	-.6922E 04
900.	-1.0800	-.1084E-01	-.1348E 00	.1818E-01	.0247	-.6675E 04
1200.	-1.5200	-.1533E-01	-.1898E 00	.3601E-01	.0347	-.6324E 04
1500.	-1.9840	-.2013E-01	-.2477E 00	.6135E-01	.0453	-.6056E 04
1800.	-3.3960	-.3504E-01	-.4240E 00	.1798E 00	.0775	-.4246E 04
2400.	-4.0960	-.4263E-01	-.5114E 00	.2615E 00	.0935	-.4693E 04
3000.	-4.5960	-.4813E-01	-.5738E 00	.3292E 00	.1049	-.5228E 04
4140.	-5.4000	-.5713E-01	-.6742E 00	.4545E 00	.1233	-.6141E 04
5400.	-6.9280	-.7476E-01	-.8649E 00	.7481E 00	.1581	-.6243E 04
7200.	-8.4080	-.9254E-01	-.1050E 01	.1102E 01	.1919	-.6859E 04
10800.	-10.9360	-.1247E 00	-.1365E 01	.1864E 01	.2496	-.7910E 04
14400.	-13.2760	-.1568E 00	-.1657E 01	.2747E 01	.3030	-.8668E 04
18000.	-15.7560	-.1936E 00	-.1967E 01	.3869E 01	.3596	-.9151E 04
21600.	-18.0200	-.2301E 00	-.2250E 01	.5061E 01	.4113	-.9601E 04
25200.	-20.0700	-.2661E 00	-.2506E 01	.6278E 01	.4581	-.1006E 05
28800.	-21.9520	-.3019E 00	-.2741E 01	.7511E 01	.5010	-.1051E 05
32400.	-23.7020	-.3382E 00	-.2959E 01	.8756E 01	.5410	-.1095E 05
36000.	-25.2240	-.3724E 00	-.3149E 01	.9917E 01	.5757	-.1143E 05
39600.	-26.6820	-.4078E 00	-.3331E 01	.1110E 02	.6090	-.1189E 05
43200.	-28.0120	-.4429E 00	-.3497E 01	.1223E 02	.6394	-.1235E 05
46800.	-29.2720	-.4790E 00	-.3654E 01	.1335E 02	.6681	-.1281E 05
50400.	-30.3920	-.5138E 00	-.3794E 01	.1440E 02	.6937	-.1328E 05
54000.	-31.3120	-.5447E 00	-.3909E 01	.1528E 02	.7147	-.1381E 05
57600.	-32.1120	-.5734E 00	-.4009E 01	.1607E 02	.7329	-.1437E 05
61200.	-33.0720	-.6106E 00	-.4129E 01	.1705E 02	.7549	-.1482E 05
64800.	-33.8720	-.6442E 00	-.4229E 01	.1788E 02	.7731	-.1532E 05
68400.	-34.5520	-.6750E 00	-.4314E 01	.1861E 02	.7886	-.1586E 05

Table CR-9 (Continued)

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
72000.	-35.3520	-.7142E 00	-.4413E 01	.1948E 02	.8069	-.1631E 05
75600.	-35.8720	-.7418E 00	-.4478E 01	.2006E 02	.8188	-.1688E 05
79200.	-36.5120	-.7783E 00	-.4558E 01	.2078E 02	.8334	-.1737E 05
82800.	-36.9520	-.8053E 00	-.4613E 01	.2128E 02	.8434	-.1795E 05
86400.	-37.4720	-.8395E 00	-.4678E 01	.2189E 02	.8553	-.1847E 05
90000.	-37.9520	-.8737E 00	-.4738E 01	.2245E 02	.8662	-.1900E 05
93600.	-38.3760	-.9063E 00	-.4791E 01	.2295E 02	.8759	-.1954E 05
97200.	-38.7760	-.9395E 00	-.4841E 01	.2343E 02	.8851	-.2008E 05
100800.	-39.1200	-.9702E 00	-.4884E 01	.2385E 02	.8929	-.2064E 05
104400.	-39.4480	-.1002E 01	-.4925E 01	.2425E 02	.9004	-.2120E 05
108000.	-39.7760	-.1036E 01	-.4966E 01	.2466E 02	.9079	-.2175E 05
111600.	-40.0400	-.1065E 01	-.4999E 01	.2499E 02	.9139	-.2233E 05
115200.	-40.4320	-.1113E 01	-.5048E 01	.2548E 02	.9229	-.2282E 05
118800.	-40.7320	-.1153E 01	-.5085E 01	.2586E 02	.9297	-.2336E 05
122400.	-41.0020	-.1193E 01	-.5119E 01	.2620E 02	.9359	-.2391E 05
126000.	-41.2120	-.1227E 01	-.5145E 01	.2647E 02	.9407	-.2449E 05
129600.	-41.4120	-.1261E 01	-.5170E 01	.2673E 02	.9452	-.2507E 05
133200.	-41.6120	-.1299E 01	-.5195E 01	.2699E 02	.9498	-.2564E 05
136800.	-41.7830	-.1334E 01	-.5216E 01	.2721E 02	.9537	-.2623E 05
140400.	-41.9520	-.1372E 01	-.5237E 01	.2743E 02	.9575	-.2681E 05
144000.	-42.0920	-.1406E 01	-.5255E 01	.2761E 02	.9607	-.2740E 05
147600.	-42.2820	-.1457E 01	-.5279E 01	.2786E 02	.9651	-.2796E 05
151200.	-42.4120	-.1495E 01	-.5295E 01	.2804E 02	.9680	-.2856E 05
154800.	-42.5320	-.1534E 01	-.5310E 01	.2819E 02	.9708	-.2915E 05
158400.	-42.6520	-.1577E 01	-.5325E 01	.2835E 02	.9735	-.2975E 05
162000.	-42.8020	-.1637E 01	-.5344E 01	.2855E 02	.9769	-.3032E 05
165600.	-42.8920	-.1678E 01	-.5355E 01	.2867E 02	.9790	-.3093E 05
169200.	-42.9520	-.1707E 01	-.5362E 01	.2875E 02	.9804	-.3155E 05
172800.	-43.0560	-.1763E 01	-.5375E 01	.2889E 02	.9827	-.3215E 05
176400.	-43.1600	-.1827E 01	-.5388E 01	.2903E 02	.9851	-.3274E 05
180000.	-43.2720	-.1909E 01	-.5402E 01	.2918E 02	.9877	-.3332E 05
183600.	-43.3520	-.1979E 01	-.5412E 01	.2929E 02	.9895	-.3392E 05
187200.	-43.4480	-.2080E 01	-.5424E 01	.2942E 02	.9917	-.3451E 05
190800.	-43.5440	-.2213E 01	-.5436E 01	.2955E 02	.9939	-.3510E 05
194400.	-43.6340	-.2391E 01	-.5447E 01	.2967E 02	.9959	-.3569E 05
198000.	-43.7320	-.2739E 01	-.5460E 01	.2981E 02	.9982	-.3627E 05
201600.	-43.8080	-.4040E 01	-.5469E 01	.2991E 02	.9999	-.3686E 05

Table ZR-1. Weight Losses for 2.85:1.00 Mole Ratio ZrO_2-Nb_2O_5 Between the Oxygen Partial Pressure Range of 5.7×10^{-2} to 1.95×10^{-14} atm. at 850°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	-.0320	-.1166E-01	-.6144E-02	.3775E-04	.0265	-.9765E 04
120.	-.0680	-.2516E-01	-.1306E-01	.1705E-03	.0563	-.9191E 04
180.	-.0760	-.2822E-01	-.1459E-01	.2130E-03	.0629	-.1233E 05
240.	-.0800	-.2976E-01	-.1536E-01	.2360E-03	.0662	-.1562E 05
300.	-.0920	-.3440E-01	-.1767E-01	.3121E-03	.0762	-.1698E 05
360.	-.0920	-.3440E-01	-.1767E-01	.3121E-03	.0762	-.2038E 05
420.	-.1000	-.3753E-01	-.1920E-01	.3687E-03	.0828	-.2187E 05
480.	-.1120	-.4226E-01	-.2151E-01	.4625E-03	.0927	-.2232E 05
540.	-.1200	-.4544E-01	-.2304E-01	.5309E-03	.0993	-.2344E 05
600.	-.1280	-.4864E-01	-.2458E-01	.6041E-03	.1060	-.2441E 05
660.	-.1320	-.5025E-01	-.2535E-01	.6424E-03	.1093	-.2604E 05
720.	-.1360	-.5187E-01	-.2611E-01	.6819E-03	.1126	-.2757E 05
780.	-.1440	-.5513E-01	-.2765E-01	.7645E-03	.1192	-.2821E 05
840.	-.1440	-.5513E-01	-.2765E-01	.7645E-03	.1192	-.3038E 05
900.	-.1520	-.5840E-01	-.2919E-01	.8518E-03	.1258	-.3084E 05
1200.	-.1800	-.7007E-01	-.3456E-01	.1195E-02	.1490	-.3472E 05
1500.	-.2000	-.7861E-01	-.3840E-01	.1475E-02	.1656	-.3906E 05
1800.	-.2240	-.8907E-01	-.4301E-01	.1850E-02	.1854	-.4185E 05
2400.	-.2740	-.1117E 00	-.5261E-01	.2768E-02	.2268	-.4562E 05
3000.	-.3000	-.1240E 00	-.5760E-01	.3318E-02	.2483	-.5208E 05
4140.	-.3160	-.1317E 00	-.6068E-01	.3682E-02	.2616	-.6823E 05
5400.	-.4000	-.1747E 00	-.7680E-01	.5899E-02	.3311	-.7031E 05
7200.	-.4700	-.2140E 00	-.9025E-01	.8144E-02	.3891	-.7978E 05
10800.	-.6000	-.2982E 00	-.1152E 00	.1327E-01	.4967	-.9374E 05
14400.	-.6280	-.3186E 00	-.1206E 00	.1454E-01	.5199	-.1194E 06
18000.	-.8120	-.4844E 00	-.1559E 00	.2431E-01	.6722	-.1154E 06
21600.	-.8840	-.5715E 00	-.1697E 00	.2881E-01	.7318	-.1273E 06
25200.	-.9440	-.6605E 00	-.1813E 00	.3286E-01	.7815	-.1390E 06
28800.	-.9880	-.7396E 00	-.1897E 00	.3599E-01	.8179	-.1518E 06
32400.	-.9920	-.7476E 00	-.1905E 00	.3628E-01	.8212	-.1701E 06
36000.	-1.0400	-.8568E 00	-.1997E 00	.3988E-01	.8609	-.1803E 06
39600.	-1.0360	-.8465E 00	-.1989E 00	.3957E-01	.8576	-.1991E 06
43200.	-1.0720	-.9485E 00	-.2058E 00	.4237E-01	.8874	-.2099E 06
46800.	-1.0960	-.1033E 01	-.2104E 00	.4429E-01	.9073	-.2224E 06
50400.	-1.1080	-.1082E 01	-.2127E 00	.4526E-01	.9172	-.2369E 06
54000.	-1.1160	-.1118E 01	-.2143E 00	.4592E-01	.9238	-.2520E 06
57600.	-1.1440	-.1276E 01	-.2197E 00	.4825E-01	.9470	-.2622E 06
61200.	-1.1520	-.1334E 01	-.2212E 00	.4893E-01	.9536	-.2767E 06
64800.	-1.1560	-.1366E 01	-.2220E 00	.4927E-01	.9570	-.2919E 06
68400.	-1.1560	-.1366E 01	-.2220E 00	.4927E-01	.9570	-.3082E 06
72000.	-1.1880	-.1781E 01	-.2281E 00	.5203E-01	.9834	-.3156E 06
75600.	-1.1960	-.2003E 01	-.2296E 00	.5274E-01	.9901	-.3292E 06
79200.	-1.1960	-.2003E 01	-.2296E 00	.5274E-01	.9901	-.3449E 06
82800.	-1.2040	-.2480E 01	-.2312E 00	.5345E-01	.9967	-.3582E 06
86400.	-1.2040	-.2480E 01	-.2312E 00	.5345E-01	.9967	-.3737E 06

Table ZR-2. Weight Losses for 2.85:1.00 Mole Ratio ZrO_2-Nb_2O_5 Between the Oxygen Partial Pressure Range of 1.95×10^{-14} to 3.88×10^{-17} atm. at 850°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	-.0040	-.8288E-03	-.7680E-03	.5899E-06	.0019	-.7812E 05
120.	.0160	.3299E-02	.3072E-02	.9438E-05	-.0076	.3906E 05
180.	.0400	.8202E-02	.7680E-02	.5899E-04	-.0191	.2344E 05
240.	.0400	.8202E-02	.7680E-02	.5899E-04	-.0191	.3125E 05
300.	.0120	.2477E-02	.2304E-02	.5309E-05	-.0057	.1302E 06
360.	.0440	.9014E-02	.8449E-02	.7138E-04	-.0210	.4261E 05
420.	.0440	.9014E-02	.8449E-02	.7138E-04	-.0210	.4971E 05
480.	.0280	.5758E-02	.5376E-02	.2891E-04	-.0133	.8929E 05
540.	.0120	.2477E-02	.2304E-02	.5309E-05	-.0057	.2344E 06
600.	-.0200	-.4160E-02	-.3840E-02	.1475E-04	.0095	-.1562E 06
660.	-.0160	-.3325E-02	-.3072E-02	.9438E-05	.0076	-.2148E 06
720.	-.0360	-.7517E-02	-.6912E-02	.4778E-04	.0172	-.1042E 06
780.	-.0480	-.1005E-01	-.9217E-02	.8495E-04	.0229	-.8463E 05
840.	-.0560	-.1175E-01	-.1075E-01	.1156E-03	.0267	-.7812E 05
900.	-.0920	-.1947E-01	-.1767E-01	.3121E-03	.0439	-.5095E 05
1200.	-.0800	-.1688E-01	-.1536E-01	.2360E-03	.0381	-.7812E 05
1500.	-.1140	-.2426E-01	-.2189E-01	.4791E-03	.0543	-.6853E 05
1800.	-.1920	-.4168E-01	-.3687E-01	.1359E-02	.0915	-.4882E 05
2400.	-.3040	-.6798E-01	-.5837E-01	.3407E-02	.1449	-.4112E 05
3000.	-.4120	-.9495E-01	-.7911E-01	.6258E-02	.1964	-.3792E 05
4140.	-.5080	-.1204E 00	-.9754E-01	.9514E-02	.2421	-.4244E 05
5400.	-.6840	-.1714E 00	-.1313E 00	.1725E-01	.3260	-.4112E 05
7200.	-.8280	-.2180E 00	-.1590E 00	.2528E-01	.3947	-.4529E 05
10800.	-1.0080	-.2844E 00	-.1935E 00	.3746E-01	.4805	-.5580E 05
14400.	-1.1200	-.3315E 00	-.2151E 00	.4625E-01	.5338	-.6696E 05
18000.	-1.2480	-.3924E 00	-.2396E 00	.5742E-01	.5949	-.7512E 05
21600.	-1.3080	-.4242E 00	-.2512E 00	.6308E-01	.6235	-.8600E 05
25200.	-1.3880	-.4705E 00	-.2665E 00	.7103E-01	.6616	-.9455E 05
28800.	-1.4680	-.5225E 00	-.2819E 00	.7945E-01	.6997	-.1022E 06
32400.	-1.5180	-.5564E 00	-.2915E 00	.8496E-01	.7235	-.1112E 06
36000.	-1.5380	-.5736E 00	-.2953E 00	.8721E-01	.7331	-.1219E 06
39600.	-1.5780	-.6058E 00	-.3030E 00	.9181E-01	.7521	-.1307E 06
43200.	-1.6180	-.6406E 00	-.3107E 00	.9652E-01	.7712	-.1391E 06
46800.	-1.6280	-.6497E 00	-.3126E 00	.9772E-01	.7760	-.1497E 06
50400.	-1.6380	-.6590E 00	-.3145E 00	.9892E-01	.7807	-.1602E 06
54000.	-1.6880	-.7090E 00	-.3241E 00	.1051E 00	.8046	-.1666E 06
57600.	-1.7080	-.7307E 00	-.3280E 00	.1076E 00	.8141	-.1756E 06
61200.	-1.7080	-.7307E 00	-.3280E 00	.1076E 00	.8141	-.1866E 06
64800.	-1.7680	-.8033E 00	-.3395E 00	.1152E 00	.8427	-.1909E 06
68400.	-1.7980	-.8447E 00	-.3452E 00	.1192E 00	.8570	-.1981E 06

Table ZR-2 (Continued)

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
72000.	-1.8280	-.8904E 00	-.3510E 00	.1232E 00	.8713	-.2051E 06
75600.	-1.8480	-.9239E 00	-.3548E 00	.1259E 00	.8808	-.2131E 06
79200.	-1.8680	-.9601E 00	-.3587E 00	.1287E 00	.8904	-.2208E 06
82800.	-1.8880	-.9996E 00	-.3625E 00	.1314E 00	.8999	-.2284E 06
86400.	-1.8880	-.9996E 00	-.3625E 00	.1314E 00	.8999	-.2383E 06
90000.	-1.8980	-.1021E 01	-.3644E 00	.1328E 00	.9047	-.2470E 06
93600.	-1.9080	-.1043E 01	-.3664E 00	.1342E 00	.9094	-.2555E 06
97200.	-1.9180	-.1067E 01	-.3683E 00	.1356E 00	.9142	-.2639E 06
100800.	-1.9280	-.1091E 01	-.3702E 00	.1370E 00	.9190	-.2723E 06
104400.	-1.9280	-.1091E 01	-.3702E 00	.1370E 00	.9190	-.2820E 06
108000.	-1.9280	-.1091E 01	-.3702E 00	.1370E 00	.9190	-.2917E 06
111600.	-1.9380	-.1118E 01	-.3721E 00	.1385E 00	.9237	-.2999E 06
115200.	-1.9380	-.1118E 01	-.3721E 00	.1385E 00	.9237	-.3096E 06
118800.	-1.9380	-.1118E 01	-.3721E 00	.1385E 00	.9237	-.3193E 06
122400.	-1.9380	-.1118E 01	-.3721E 00	.1385E 00	.9237	-.3289E 06
126000.	-1.9580	-.1176E 01	-.3760E 00	.1413E 00	.9333	-.3351E 06
129600.	-1.9880	-.1280E 01	-.3817E 00	.1457E 00	.9476	-.3395E 06
133200.	-1.9880	-.1280E 01	-.3817E 00	.1457E 00	.9476	-.3489E 06
136800.	-1.9980	-.1322E 01	-.3836E 00	.1472E 00	.9523	-.3565E 06
140400.	-1.9980	-.1322E 01	-.3836E 00	.1472E 00	.9523	-.3660E 06
144000.	-1.9980	-.1322E 01	-.3836E 00	.1472E 00	.9523	-.3754E 06
147600.	-1.9980	-.1322E 01	-.3836E 00	.1472E 00	.9523	-.3847E 06
151200.	-2.0180	-.1419E 01	-.3875E 00	.1501E 00	.9619	-.3902E 06
154800.	-2.0280	-.1477E 01	-.3894E 00	.1516E 00	.9666	-.3975E 06
158400.	-2.0480	-.1623E 01	-.3932E 00	.1546E 00	.9762	-.4028E 06
162000.	-2.0480	-.1623E 01	-.3932E 00	.1546E 00	.9762	-.4120E 06
165600.	-2.0480	-.1623E 01	-.3932E 00	.1546E 00	.9762	-.4211E 06
169200.	-2.0680	-.1845E 01	-.3971E 00	.1577E 00	.9857	-.4261E 06
172800.	-2.0680	-.1845E 01	-.3971E 00	.1577E 00	.9857	-.4352E 06
176400.	-2.0880	-.2322E 01	-.4009E 00	.1607E 00	.9952	-.4400E 06
180000.	-2.0880	-.2322E 01	-.4009E 00	.1607E 00	.9952	-.4490E 06
183600.	-2.0880	-.2322E 01	-.4009E 00	.1607E 00	.9952	-.4579E 06

Table ZR-3. Weight Losses for 2.85:1.00 Mole Ratio ZrO_2-Nb_2O_5 Between the O gen Partial Pressure Range of 3.88×10^{-17} to 2.11×10^{-19} Atm. at 850°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	.0080	.1174E-02	.1536E-02	.2360E-05	-.0027	.3906E 05
120.	.0920	.1331E-01	.1767E-01	.3121E-03	-.0311	.6793E 04
180.	.1360	.1954E-01	.2611E-01	.6819E-03	-.0460	.6893E 04
240.	.1640	.2345E-01	.3149E-01	.9916E-03	-.0555	.7621E 04
300.	.1800	.2567E-01	.3456E-01	.1195E-02	-.0609	.8880E 04
360.	.1880	.2678E-01	.3610E-01	.1303E-02	-.0636	.9973E 04
420.	.1960	.2788E-01	.3763E-01	.1416E-02	-.0663	.1115E 05
480.	.2000	.2843E-01	.3840E-01	.1475E-02	-.0677	.1250E 05
540.	.1920	.2733E-01	.3687E-01	.1359E-02	-.0650	.1465E 05
600.	.1880	.2678E-01	.3610E-01	.1303E-02	-.0636	.1662E 05
660.	.1800	.2567E-01	.3456E-01	.1195E-02	-.0609	.1910E 05
720.	.1800	.2567E-01	.3456E-01	.1195E-02	-.0609	.2083E 05
780.	.1720	.2456E-01	.3303E-01	.1091E-02	-.0582	.2362E 05
840.	.1600	.2289E-01	.3072E-01	.9438E-03	-.0541	.2734E 05
900.	.1560	.2234E-01	.2995E-01	.8972E-03	-.0528	.3005E 05
1200.	.0880	.1274E-01	.1690E-01	.2855E-03	-.0298	.7102E 05
1500.	.0160	.2344E-02	.3072E-02	.9438E-05	-.0054	.4883E 06
1800.	-.0520	-.7708E-02	-.9985E-02	.9969E-04	.0176	-.1803E 06
2400.	-.1680	-.2541E-01	-.3226E-01	.1041E-02	.0568	-.7440E 05
3000.	-.2720	-.4192E-01	-.5223E-01	.2728E-02	.0920	-.5744E 05
4140.	-.3240	-.5042E-01	-.6221E-01	.3870E-02	.1096	-.6655E 05
5400.	-.5160	-.8331E-01	-.9908E-01	.9817E-02	.1746	-.5453E 05
7200.	-.6640	-.1105E 00	-.1275E 00	.1626E-01	.2246	-.5647E 05
10800.	-.9040	-.1585E 00	-.1736E 00	.3013E-01	.3058	-.6222E 05
14400.	-1.0960	-.2012E 00	-.2104E 00	.4429E-01	.3708	-.6843E 05
18000.	-1.2280	-.2332E 00	-.2358E 00	.5560E-01	.4154	-.7634E 05
21600.	-1.3560	-.2666E 00	-.2604E 00	.6779E-01	.4587	-.8296E 05
25200.	-1.4920	-.3052E 00	-.2865E 00	.8207E-01	.5047	-.8796E 05
28800.	-1.5920	-.3359E 00	-.3057E 00	.9344E-01	.5386	-.9422E 05
32400.	-1.7000	-.3717E 00	-.3264E 00	.1066E 00	.5751	-.9926E 05
36000.	-1.7880	-.4033E 00	-.3433E 00	.1179E 00	.6049	-.1049E 06
39600.	-1.8840	-.4405E 00	-.3618E 00	.1309E 00	.6373	-.1095E 06
43200.	-1.9720	-.4777E 00	-.3786E 00	.1434E 00	.6671	-.1141E 06
46800.	-2.0320	-.5050E 00	-.3902E 00	.1522E 00	.6874	-.1199E 06
50400.	-2.0960	-.5362E 00	-.4025E 00	.1620E 00	.7091	-.1252E 06
54000.	-2.1720	-.5764E 00	-.4171E 00	.1739E 00	.7348	-.1295E 06
57600.	-2.2200	-.6038E 00	-.4263E 00	.1817E 00	.7510	-.1351E 06
61200.	-2.2600	-.6281E 00	-.4339E 00	.1883E 00	.7645	-.1410E 06
64800.	-2.3320	-.6755E 00	-.4478E 00	.2005E 00	.7889	-.1447E 06
68400.	-2.3880	-.7164E 00	-.4585E 00	.2102E 00	.8078	-.1492E 06

Table ZR-3 (Continued)

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
72000.	-2.4720	-.7859E 00	-.4747E 00	.2253E 00	.8363	-.1517E 06
75600.	-2.5320	-.8433E 00	-.4862E 00	.2364E 00	.8566	-.1555E 06
79200.	-2.6040	-.9242E 00	-.5000E 00	.2500E 00	.8809	-.1584E 06
82800.	-2.6840	-.1036E 01	-.5154E 00	.2656E 00	.9080	-.1607E 06
86400.	-2.7880	-.1245E 01	-.5353E 00	.2866E 00	.9432	-.1614E 06
90000.	-2.9120	-.1827E 01	-.5591E 00	.3126E 00	.9851	-.1610E 06
9[illegible]00.	-2.8920	-.1665E 01	-.5553E 00	.3084E 00	.9783	-.1686E 06
97200.	-2.8920	-.1665E 01	-.5553E 00	.3084E 00	.9783	-.1750E 06
100800.	-2.9160	-.1869E 01	-.5599E 00	.3135E 00	.9865	-.1800E 06
104400.	-2.9520	-.2869E 01	-.5668E 00	.3213E 00	.9986	-.1842E 06

Table ZR-4. Weight Losses for 2.85:1.00 Mole Ratio ZrO_2-Nb_2O_5 Between the Oxygen Partial Pressure Range of 4.8×10^{-2} to 1.71×10^{-11} Atm. at 1000°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	-.0200	-.9067E-02	-.3840E-02	.1475E-04	.0207	-.1562E 05
120.	-.0400	-.1833E-01	-.7580E-02	.5899E-04	.0413	-.1562E 05
180.	-.0560	-.2588E-01	-.1075E-01	.1156E-03	.0579	-.1674E 05
240.	-.0520	-.2398E-01	-.9985E-02	.9969E-04	.0537	-.2404E 05
300.	-.0680	-.3163E-01	-.1306E-01	.1705E-03	.0702	-.2298E 05
360.	-.0800	-.3746E-01	-.1536E-01	.2360E-03	.0826	-.2344E 05
420.	-.0900	-.4238E-01	-.1728E-01	.2986E-03	.0930	-.2430E 05
480.	-.1040	-.4936E-01	-.1997E-01	.3988E-03	.1074	-.2404E 05
540.	-.1200	-.5748E-01	-.2304E-01	.5309E-03	.1240	-.2344E 05
600.	-.1320	-.6367E-01	-.2535E-01	.6424E-03	.1364	-.2367E 05
660.	-.1400	-.6785E-01	-.2688E-01	.7226E-03	.1446	-.2455E 05
720.	-.1480	-.7206E-01	-.2842E-01	.8076E-03	.1529	-.2534E 05
780.	-.1520	-.7419E-01	-.2919E-01	.8518E-03	.1570	-.2673E 05
840.	-.1560	-.7632E-01	-.2995E-01	.8972E-03	.1612	-.2804E 05
900.	-.1600	-.7846E-01	-.3072E-01	.9438E-03	.1653	-.2929E 05
1200.	-.1920	-.9601E-01	-.3687E-01	.1359E-02	.1983	-.3255E 05
1500.	-.2080	-.1051E 00	-.3994E-01	.1595E-02	.2149	-.3756E 05
1800.	-.2320	-.1190E 00	-.4455E-01	.1984E-02	.2397	-.4041E 05
2400.	-.2480	-.1285E 00	-.4762E-01	.2268E-02	.2562	-.5040E 05
3000.	-.2640	-.1383E 00	-.5069E-01	.2570E-02	.2727	-.5918E 05
4140.	-.2920	-.1559E 00	-.5607E-01	.3144E-02	.3017	-.7384E 05
5400.	-.3720	-.2106E 00	-.7143E-01	.5102E-02	.3843	-.7560E 05
7200.	-.4040	-.2346E 00	-.7757E-01	.6018E-02	.4174	-.9282E 05
10800.	-.4400	-.2632E 00	-.8449E-01	.7138E-02	.4545	-.1278E 06
14400.	-.5280	-.3424E 00	-.1014E 00	.1028E-01	.5455	-.1420E 06
18000.	-.7000	-.5577E 00	-.1344E 00	.1807E-01	.7231	-.1339E 06
21600.	-.7400	-.6279E 00	-.1421E 00	.2019E-01	.7645	-.1520E 06
25200.	-.8120	-.7928E 00	-.1559E 00	.2431E-01	.8388	-.1616E 06
28800.	-.8280	-.8397E 00	-.1590E 00	.2528E-01	.8554	-.1811E 06
32400.	-.8520	-.9214E 00	-.1636E 00	.2676E-01	.8802	-.1981E 06
36000.	-.8600	-.9525E 00	-.1651E 00	.2727E-01	.8884	-.2180E 06
39600.	-.8840	-.1062E 01	-.1697E 00	.2881E-01	.9132	-.2333E 06
43200.	-.8920	-.1105E 01	-.1713E 00	.2934E-01	.9215	-.2522E 06
46800.	-.9160	-.1270E 01	-.1759E 00	.3093E-01	.9463	-.2661E 06
50400.	-.9240	-.1342E 01	-.1774E 00	.3148E-01	.9545	-.2841E 06
54000.	-.9320	-.1430E 01	-.1790E 00	.3203E-01	.9628	-.3018E 06
57600.	-.9400	-.1539E 01	-.1805E 00	.3258E-01	.9711	-.3191E 06
61200.	-.9480	-.1685E 01	-.1820E 00	.3313E-01	.9793	-.3362E 06
64800.	-.9560	-.1907E 01	-.1836E 00	.3370E-01	.9876	-.3530E 06
68400.	-.9640	-.2384E 01	-.1851E 00	.3426E-01	.9959	-.3695E 06
72000.	-.9640	-.2384E 01	-.1851E 00	.3426E-01	.9959	-.3890E 06
75600.	-.9640	-.2384E 01	-.1851E 00	.3426E-01	.9959	-.4084E 06

Table ZR-5. Weight Losses for 2.85:1.00 Mole Ratio ZrO_2-Nb_2O_5 Between the Oxygen Partial Pressure Range of 1.71×10^{-11} to 3.73×10^{-14} Atm. at 1000°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	.0120	.2518E-02	.2304E-02	.5309E-05	-.0058	.2604E 05
120.	.0320	.6682E-02	.6144E-02	.3775E-04	-.0155	.1953E 05
180.	.0400	.8336E-02	.7680E-02	.5899E-04	-.0194	.2344E 05
240.	.0520	.1081E-01	.9985E-02	.9969E-04	-.0252	.2404E 05
300.	.0640	.1326E-01	.1229E-01	.1510E-03	-.0310	.2441E 05
360.	.0680	.1408E-01	.1306E-01	.1705E-03	-.0329	.2757E 05
420.	.0720	.1489E-01	.1382E-01	.1911E-03	-.0349	.3038E 05
480.	.0680	.1408E-01	.1306E-01	.1705E-03	-.0329	.3676E 05
540.	.0480	.9984E-02	.9217E-02	.8495E-04	-.0233	.5859E 05
600.	.0360	.7510E-02	.6912E-02	.4778E-04	-.0174	.8680E 05
660.	.0160	.3354E-02	.3072E-02	.9438E-05	-.0078	.2148E 06
720.	.0080	.1680E-02	.1536E-02	.2360E-05	-.0039	.4687E 06
780.	-.0120	-.2532E-02	-.2304E-02	.5309E-05	.0058	-.3385E 06
840.	-.0160	-.3380E-02	-.3072E-02	.9438E-05	.0078	-.2734E 06
900.	-.0280	-.5932E-02	-.5376E-02	.2891E-04	.0136	-.1674E 06
1200.	-.0800	-.1717E-01	-.1536E-01	.2360E-03	.0388	-.7812E 05
1500.	-.1400	-.3050E-01	-.2688E-01	.7226E-03	.0678	-.5580E 05
1800.	-.2200	-.4895E-01	-.4224E-01	.1784E-02	.1066	-.4261E 05
2400.	-.3200	-.7316E-01	-.6144E-01	.3775E-02	.1550	-.3906E 05
3000.	-.4080	-.9565E-01	-.7834E-01	.6137E-02	.1977	-.3829E 05
4140.	-.4480	-.1063E 00	-.8602E-01	.7400E-02	.2171	-.4813E 05
5400.	-.6160	-.1539E 00	-.1183E 00	.1399E-01	.2984	-.4565E 05
7200.	-.7200	-.1863E 00	-.1382E 00	.1911E-01	.3488	-.5208E 05
10800.	-.8400	-.2269E 00	-.1613E 00	.2601E-01	.4070	-.6696E 05
14400.	-1.0240	-.2977E 00	-.1966E 00	.3866E-01	.4961	-.7324E 05
18000.	-1.1120	-.3361E 00	-.2135E 00	.4559E-01	.5388	-.8430E 05
21600.	-1.2000	-.3762E 00	-.2304E 00	.5309E-01	.5814	-.9374E 05
25200.	-1.2680	-.4138E 00	-.2435E 00	.5928E-01	.6143	-.1035E 06
28800.	-1.3240	-.4455E 00	-.2542E 00	.6463E-01	.6415	-.1133E 06
32400.	-1.3720	-.4746E 00	-.2634E 00	.6940E-01	.6647	-.1230E 06
36000.	-1.3880	-.4848E 00	-.2665E 00	.7103E-01	.6725	-.1351E 06
39600.	-1.4360	-.5168E 00	-.2757E 00	.7603E-01	.6957	-.1436E 06
43200.	-1.4680	-.5395E 00	-.2819E 00	.7945E-01	.7112	-.1533E 06
46800.	-1.5080	-.5696E 00	-.2896E 00	.8384E-01	.7306	-.1616E 06
50400.	-1.5480	-.6021E 00	-.2972E 00	.8835E-01	.7500	-.1696E 06
54000.	-1.5720	-.6227E 00	-.3018E 00	.9111E-01	.7616	-.1789E 06
57600.	-1.5880	-.6371E 00	-.3049E 00	.9297E-01	.7694	-.1889E 06
61200.	-1.6120	-.6596E 00	-.3095E 00	.9580E-01	.7810	-.1977E 06
64800.	-1.6280	-.6752E 00	-.3126E 00	.9772E-01	.7888	-.2073E 06
68400.	-1.6440	-.6915E 00	-.3157E 00	.9965E-01	.7965	-.2167E 06

Table ZR-5 (Continued)

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
72000.	-1.6680	-.7170E 00	-.3203E 00	.1026E 00	.8081	-.2248E 06
75600.	-1.6760	-.7259E 00	-.3218E 00	.1036E 00	.8120	-.2349E 06
79200.	-1.7000	-.7536E 00	-.3264E 00	.1066E 00	.8236	-.2426E 06
82800.	-1.7080	-.7633E 00	-.3280E 00	.1076E 00	.8275	-.2525E 06
86400.	-1.7240	-.7832E 00	-.3310E 00	.1096E 00	.8353	-.2610E 06
90000.	-1.7320	-.7936E 00	-.3326E 00	.1106E 00	.8391	-.2706E 06
93600.	-1.7400	-.8042E 00	-.3341E 00	.1116E 00	.8430	-.2802E 06
97200.	-1.7480	-.8150E 00	-.3356E 00	.1127E 00	.8469	-.2896E 06
100800.	-1.7520	-.8206E 00	-.3364E 00	.1132E 00	.8488	-.2996E 06
104400.	-1.7720	-.8493E 00	-.3402E 00	.1158E 00	.8585	-.3068E 06
108000.	-1.7840	-.8676E 00	-.3425E 00	.1173E 00	.8643	-.3153E 06
111600.	-1.8040	-.8997E 00	-.3464E 00	.1200E 00	.8740	-.3222E 06
115200.	-1.8120	-.9133E 00	-.3479E 00	.1211E 00	.8779	-.3311E 06
118800.	-1.8120	-.9133E 00	-.3479E 00	.1211E 00	.8779	-.3415E 06
122400.	-1.8360	-.9568E 00	-.3525E 00	.1243E 00	.8895	-.3472E 06
126000.	-1.8440	-.9723E 00	-.3541E 00	.1254E 00	.8934	-.3559E 06
129600.	-1.8520	-.9884E 00	-.3556E 00	.1265E 00	.8973	-.3644E 06
133200.	-1.8600	-.1005E 01	-.3571E 00	.1276E 00	.9012	-.3730E 06
136800.	-1.8760	-.1041E 01	-.3602E 00	.1298E 00	.9089	-.3798E 06
140400.	-1.8760	-.1041E 01	-.3602E 00	.1298E 00	.9089	-.3898E 06
144000.	-1.8760	-.1041E 01	-.3602E 00	.1298E 00	.9089	-.3998E 06
147600.	-1.8760	-.1041E 01	-.3602E 00	.1298E 00	.9089	-.4098E 06
151200.	-1.8920	-.1079E 01	-.3633E 00	.1320E 00	.9167	-.4162E 06
154800.	-1.9080	-.1122E 01	-.3664E 00	.1342E 00	.9244	-.4225E 06
158400.	-1.9320	-.1194E 01	-.3710E 00	.1376E 00	.9360	-.4270E 06
162000.	-1.9280	-.1181E 01	-.3702E 00	.1370E 00	.9341	-.4376E 06
165600.	-1.9280	-.1181E 01	-.3702E 00	.1370E 00	.9341	-.4473E 06
169200.	-1.9320	-.1194E 01	-.3710E 00	.1376E 00	.9360	-.4561E 06
172800.	-1.9280	-.1181E 01	-.3702E 00	.1370E 00	.9341	-.4668E 06
176400.	-1.9320	-.1194E 01	-.3710E 00	.1376E 00	.9360	-.4755E 06
180000.	-1.9400	-.1221E 01	-.3725E 00	.1388E 00	.9399	-.4832E 06
183600.	-1.9480	-.1250E 01	-.3740E 00	.1399E 00	.9438	-.4909E 06
187200.	-1.9480	-.1250E 01	-.3740E 00	.1399E 00	.9438	-.5005E 06
190800.	-1.9640	-.1315E 01	-.3771E 00	.1422E 00	.9516	-.5060E 06
194400.	-1.9800	-.1390E 01	-.3802E 00	.1445E 00	.9593	-.5113E 06
198000.	-1.9800	-.1390E 01	-.3802E 00	.1445E 00	.9593	-.5208E 06
201600.	-1.9880	-.1434E 01	-.3817E 00	.1457E 00	.9632	-.5281E 06
205200.	-1.9880	-.1434E 01	-.3817E 00	.1457E 00	.9632	-.5376E 06
208800.	-1.9880	-.1434E 01	-.3817E 00	.1457E 00	.9632	-.5470E 06
212400.	-2.0040	-.1537E 01	-.3848E 00	.1481E 00	.9709	-.5520E 06
216000.	-2.0280	-.1758E 01	-.3894E 00	.1516E 00	.9826	-.5547E 06
219600.	-2.0280	-.1758E 01	-.3894E 00	.1516E 00	.9826	-.5639E 06
223200.	-2.0280	-.1758E 01	-.3894E 00	.1516E 00	.9826	-.5732E 06
226800.	-2.0280	-.1758E 01	-.3894E 00	.1516E 00	.9826	-.5824E 06

Table ZR-6. Weight Losses for 2.85:1.00 Mole Ratio ZrO_2-Nb_2O_5 Between the Oxygen Partial Pressure Range of 3.73×10^{-14} to 1.97×10^{-16} Atm. at 1000°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	.0240	.3257E-02	.4608E-02	.2124E-04	-.0075	.1302E 05
120.	.0480	.6490E-02	.9217E-02	.8495E-04	-.0151	.1302E 05
180.	.0640	.8632E-02	.1229E-01	.1510E-03	-.0201	.1465E 05
240.	.0720	.9699E-02	.1382E-01	.1911E-03	-.0226	.1736E 05
300.	.0760	.1023E-01	.1459E-01	.2130E-03	-.0238	.2056E 05
360.	.0800	.1076E-01	.1536E-01	.2360E-03	-.0251	.2344E 05
420.	.0800	.1076E-01	.1536E-01	.2360E-03	-.0251	.2734E 05
480.	.0600	.8098E-02	.1152E-01	.1327E-03	-.0188	.4166E 05
540.	.0480	.6490E-02	.9217E-02	.8495E-04	-.0151	.5859E 05
600.	.0400	.5415E-02	.7680E-02	.5899E-04	-.0125	.7812E 05
660.	.0280	.3798E-02	.5376E-02	.2891E-04	-.0088	.1228E 06
720.	.0160	.2174E-02	.3072E-02	.9438E-05	-.0050	.2344E 06
780.	.0000	.0000E 00	.0000E 00	.0000E 00	.0000	.7800E 03
840.	-.0040	-.5453E-03	-.7680E-03	.5899E-06	.0013	-.1094E 07
900.	-.0160	-.2185E-02	-.3072E-02	.9438E-05	.0050	-.2929E 06
1200.	-.1000	-.1384E-01	-.1920E-01	.3687E-03	.0314	-.6250E 05
1500.	-.1800	-.2524E-01	-.3456E-01	.1195E-02	.0565	-.4340E 05
1800.	-.2600	-.3695E-01	-.4992E-01	.2492E-02	.0816	-.3606E 05
2400.	-.3840	-.5574E-01	-.7373E-01	.5437E-02	.1205	-.3255E 05
3000.	-.4880	-.7215E-01	-.9370E-01	.8780E-02	.1531	-.3202E 05
4140.	-.5680	-.8522E-01	-.1091E 00	.1189E-01	.1782	-.3796E 05
5400.	-.7920	-.1240E 00	-.1521E 00	.2313E-01	.2484	-.3551E 05
7200.	-.9680	-.1572E 00	-.1859E 00	.3455E-01	.3036	-.3874E 05
10800.	-1.2480	-.2157E 00	-.2396E 00	.5742E-01	.3915	-.4507E 05
14400.	-1.4520	-.2640E 00	-.2788E 00	.7773E-01	.4555	-.5165E 05
18000.	-1.6200	-.3082E 00	-.3111E 00	.9676E-01	.5082	-.5787E 05
21600.	-1.7520	-.3464E 00	-.3364E 00	.1132E 00	.5496	-.6421E 05
25200.	-1.9040	-.3950E 00	-.3656E 00	.1337E 00	.5972	-.6893E 05
28800.	-1.9980	-.4280E 00	-.3836E 00	.1472E 00	.6267	-.7507E 05
32400.	-2.1220	-.4758E 00	-.4075E 00	.1660E 00	.6656	-.7952E 05
36000.	-2.2040	-.5105E 00	-.4232E 00	.1791E 00	.6913	-.8507E 05
39600.	-2.3120	-.5610E 00	-.4439E 00	.1971E 00	.7252	-.8920E 05
43200.	-2.4040	-.6092E 00	-.4616E 00	.2131E 00	.7541	-.9359E 05
46800.	-2.4840	-.6559E 00	-.4770E 00	.2275E 00	.7792	-.9812E 05
50400.	-2.5640	-.7063E 00	-.4923E 00	.2424E 00	.8043	-.1024E 06
54000.	-2.6280	-.7553E 00	-.5046E 00	.2546E 00	.8243	-.1070E 06
57600.	-2.6920	-.8080E 00	-.5169E 00	.2672E 00	.8444	-.1114E 06
61200.	-2.8040	-.9192E 00	-.5384E 00	.2899E 00	.8795	-.1137E 06
64800.	-2.8440	-.9670E 00	-.5461E 00	.2982E 00	.8921	-.1187E 06
68400.	-2.8600	-.9876E 00	-.5492E 00	.3016E 00	.8971	-.1246E 06
72000.	-2.9400	-.1109E 01	-.5645E 00	.3187E 00	.9222	-.1275E 06
75600.	-3.0120	-.1258E 01	-.5783E 00	.3345E 00	.9448	-.1307E 06
79200.	-3.0360	-.1322E 01	-.5829E 00	.3398E 00	.9523	-.1359E 06
82800.	-3.0440	-.1345E 01	-.5845E 00	.3416E 00	.9548	-.1417E 06
86400.	-3.1840	-.2901E 01	-.6114E 00	.3738E 00	.9987	-.1413E 06

Astronuclear Laboratory

Table ZR-7. Weight Losses for 2.85:1.00 Mole Ratio ZrO_2-Nb_2O_5 Between the Oxygen Partial Pressure Range of 5.6×10^{-2} to 7.02×10^{-9} Atm. at 1175°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	-.0160	-.7346E-02	-.3072E-02	.9438E-05	.0168	-.1953E 05
120.	-.0440	-.2051E-01	-.8449E-02	.7138E-04	.0461	-.1420E 05
180.	-.0840	-.4003E-01	-.1613E-01	.2601E-03	.0881	-.1116E 05
240.	-.1080	-.5218E-01	-.2074E-01	.4300E-03	.1132	-.1157E 05
300.	-.1280	-.6257E-01	-.2458E-01	.6041E-03	.1342	-.1221E 05
360.	-.1520	-.7537E-01	-.2919E-01	.8518E-03	.1593	-.1233E 05
420.	-.1720	-.8654E-01	-.3303E-01	.1091E-02	.1803	-.1272E 05
480.	-.1960	-.9968E-01	-.3763E-01	.1416E-02	.2055	-.1275E 05
540.	-.2080	-.1068E 00	-.3994E-01	.1595E-02	.2180	-.1352E 05
600.	-.2240	-.1162E 00	-.4301E-01	.1850E-02	.2348	-.1395E 05
660.	-.2400	-.1259E 00	-.4608E-01	.2124E-02	.2516	-.1432E 05
720.	-.2720	-.1458E 00	-.5223E-01	.2728E-02	.2851	-.1379E 05
780.	-.2920	-.1587E 00	-.5507E-01	.3144E-02	.3061	-.1391E 05
840.	-.3160	-.1747E 00	-.6068E-01	.3682E-02	.3312	-.1384E 05
900.	-.3360	-.1886E 00	-.6452E-01	.4162E-02	.3522	-.1395E 05
1200.	-.3920	-.2298E 00	-.7527E-01	.5665E-02	.4109	-.1594E 05
1500.	-.4080	-.2424E 00	-.7834E-01	.6137E-02	.4277	-.1915E 05
1800.	-.4240	-.2553E 00	-.8141E-01	.6628E-02	.4444	-.2211E 05
2400.	-.4600	-.2858E 00	-.8833E-01	.7801E-02	.4822	-.2717E 05
3000.	-.5120	-.3341E 00	-.9831E-01	.9665E-02	.5367	-.3052E 05
4140.	-.5680	-.3930E 00	-.1091E 00	.1189E-01	.5954	-.3796E 05
5400.	-.6440	-.4882E 00	-.1237E 00	.1529E-01	.6751	-.4367E 05
7200.	-.6820	-.5450E 00	-.1310E 00	.1715E-01	.7149	-.5498E 05
10800.	-.7360	-.6411E 00	-.1413E 00	.1997E-01	.7715	-.7642E 05
14400.	-.7960	-.7809E 00	-.1528E 00	.2336E-01	.8344	-.9422E 05
18000.	-.8000	-.7920E 00	-.1536E 00	.2360E-01	.8386	-.1172E 06
21600.	-.8000	-.7920E 00	-.1536E 00	.2360E-01	.8386	-.1406E 06
25200.	-.8240	-.8656E 00	-.1582E 00	.2503E-01	.8637	-.1593E 06
28800.	-.8640	-.1025E 01	-.1659E 00	.2752E-01	.9057	-.1736E 06
32400.	-.8800	-.1110E 01	-.1690E 00	.2855E-01	.9224	-.1917E 06
36000.	-.8880	-.1160E 01	-.1705E 00	.2907E-01	.9308	-.2111E 06
39600.	-.9120	-.1356E 01	-.1751E 00	.3067E-01	.9560	-.2261E 06
43200.	-.9000	-.1247E 01	-.1728E 00	.2986E-01	.9434	-.2500E 06
46800.	-.9000	-.1247E 01	-.1728E 00	.2986E-01	.9434	-.2708E 06
50400.	-.9280	-.1565E 01	-.1782E 00	.3175E-01	.9727	-.2828E 06
54000.	-.9280	-.1565E 01	-.1782E 00	.3175E-01	.9727	-.3031E 06
57600.	-.9280	-.1565E 01	-.1782E 00	.3175E-01	.9727	-.3233E 06
61200.	-.9280	-.1565E 01	-.1782E 00	.3175E-01	.9727	-.3435E 06
64800.	-.9280	-.1565E 01	-.1782E 00	.3175E-01	.9727	-.3637E 06
68400.	-.9520	-.2679E 01	-.1828E 00	.3341E-01	.9979	-.3742E 06
72000.	-.9360	-.1724E 01	-.1797E 00	.3230E-01	.9811	-.4006E 06
75600.	-.9550	-.2980E 01	-.1834E 00	.3363E-01	1.0010	-.4123E 06

Table ZR-8. Weight Losses for 2.85:1.00 Mole Ratio ZrO_2-Nb_2O_5 Between the Oxygen Partial Pressure Range of 7.02×10^{-9} to 1.06×10^{-11} Atm. at 1175°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	-.0320	-.7738E-02	-.6144E-02	.3775E-04	.0177	-.9765E 04
120.	-.0600	-.1462E-01	-.1152E-01	.1327E-03	.0331	-.1042E 05
180.	-.0880	-.2162E-01	-.1690E-01	.2855E-03	.0486	-.1065E 05
240.	-.1080	-.2669E-01	-.2074E-01	.4300E-03	.0596	-.1157E 05
300.	-.1440	-.3596E-01	-.2765E-01	.7645E-03	.0795	-.1085E 05
360.	-.1800	-.4544E-01	-.3456E-01	.1195E-02	.0993	-.1042E 05
420.	-.2240	-.5731E-01	-.4301E-01	.1850E-02	.1236	-.9765E 04
480.	-.2600	-.6727E-01	-.4992E-01	.2492E-02	.1435	-.9615E 04
540.	-.2880	-.7517E-01	-.5530E-01	.3058E-02	.1589	-.9765E 04
600.	-.3080	-.8091E-01	-.5914E-01	.3498E-02	.1700	-.1015E 05
660.	-.3440	-.9143E-01	-.6605E-01	.4363E-02	.1898	-.9992E 04
720.	-.3800	-.1022E 00	-.7296E-01	.5324E-02	.2097	-.9868E 04
780.	-.4200	-.1145E 00	-.8065E-01	.6504E-02	.2318	-.9672E 04
840.	-.4480	-.1233E 00	-.8602E-01	.7400E-02	.2472	-.9765E 04
900.	-.4840	-.1350E 00	-.9293E-01	.8637E-02	.2671	-.9684E 04
1200.	-.5760	-.1661E 00	-.1106E 00	.1223E-01	.3179	-.1085E 05
1500.	-.6680	-.1997E 00	-.1283E 00	.1645E-01	.3687	-.1169E 05
1800.	-.7660	-.2386E 00	-.1471E 00	.2163E-01	.4227	-.1224E 05
2400.	-.9160	-.3059E 00	-.1759E 00	.3093E-01	.5055	-.1365E 05
3000.	-1.0040	-.3507E 00	-.1928E 00	.3716E-01	.5541	-.1556E 05
4140.	-1.0880	-.3984E 00	-.2089E 00	.4364E-01	.6004	-.1982E 05
5400.	-1.2780	-.5306E 00	-.2454E 00	.6022E-01	.7053	-.2201E 05
7200.	-1.3680	-.6108E 00	-.2627E 00	.6900E-01	.7550	-.2741E 05
10800.	-1.5160	-.7869E 00	-.2911E 00	.8473E-01	.8366	-.3710E 05
14400.	-1.5720	-.8779E 00	-.3018E 00	.9111E-01	.8675	-.4771E 05
18000.	-1.5760	-.8852E 00	-.3026E 00	.9157E-01	.8698	-.5948E 05
21600.	-1.6560	-.1065E 01	-.3180E 00	.1011E 00	.9139	-.6793E 05
25200.	-1.7280	-.1334E 01	-.3318E 00	.1101E 00	.9536	-.7595E 05
28800.	-1.7560	-.1510E 01	-.3372E 00	.1137E 00	.9691	-.8542E 05
32400.	-1.7880	-.1878E 01	-.3433E 00	.1179E 00	.9868	-.9437E 05
36000.	-1.7880	-.1878E 01	-.3433E 00	.1179E 00	.9868	-.1049E 06
39600.	-1.8080	-.2656E 01	-.3472E 00	.1205E 00	.9978	-.1141E 06
43200.	-1.8320	-.1957E 01	-.3518E 00	.1237E 00	1.0110	-.1228E 06

Astronuclear Laboratory

Table ZR-9. Weight Losses for 2.85:1.00 Mole Ratio ZrO_2-Nb_2O_5 Between the Oxygen Partial Pressure Range of 1.06×10^{-11} to 8.64×10^{-14} Atm. at 1175°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	.0000	.0000E 00	.0000E 00	.0000E 00	.0000	.6000E 02
120.	-.0120	-.6025E-03	-.2304E-02	.5309E-05	.0014	-.5208E 05
180.	-.0520	-.2617E-02	-.9985E-02	.9969E-04	.0060	-.1803E 05
240.	-.0880	-.4438E-02	-.1690E-01	.2855E-03	.0102	-.1420E 05
300.	-.1360	-.6878E-02	-.2611E-01	.6819E-03	.0157	-.1149E 05
360.	-.1800	-.9126E-02	-.3456E-01	.1195E-02	.0208	-.1042E 05
420.	-.2160	-.1097E-01	-.4147E-01	.1720E-02	.0250	-.1013E 05
480.	-.2520	-.1283E-01	-.4839E-01	.2341E-02	.0291	-.9920E 04
540.	-.2880	-.1470E-01	-.5530E-01	.3058E-02	.0333	-.9765E 04
600.	-.3480	-.1782E-01	-.6682E-01	.4465E-02	.0402	-.8979E 04
660.	-.4000	-.2055E-01	-.7680E-01	.5899E-02	.0462	-.8593E 04
720.	-.4360	-.2245E-01	-.8372E-01	.7009E-02	.0504	-.8600E 04
780.	-.4720	-.2435E-01	-.9063E-01	.8214E-02	.0545	-.8606E 04
840.	-.5160	-.2669E-01	-.9908E-01	.9817E-02	.0596	-.8478E 04
900.	-.5600	-.2905E-01	-.1075E 00	.1156E-01	.0647	-.8370E 04
1200.	-.8080	-.4256E-01	-.1551E 00	.2407E-01	.0933	-.7735E 04
1500.	-1.1200	-.6018E-01	-.2151E 00	.4625E-01	.1294	-.6975E 04
1800.	-1.3040	-.7091E-01	-.2504E 00	.6269E-01	.1506	-.7189E 04
2400.	-1.5960	-.8851E-01	-.3065E 00	.9391E-01	.1844	-.7832E 04
3000.	-1.8800	-.1063E 00	-.3610E 00	.1303E 00	.2172	-.8311E 04
4140.	-2.1240	-.1223E 00	-.4078E 00	.1663E 00	.2454	-.1015E 05
5400.	-2.6880	-.1615E 00	-.5161E 00	.2664E 00	.3105	-.1046E 05
7200.	-3.1360	-.1954E 00	-.6022E 00	.3626E 00	.3623	-.1196E 05
10800.	-3.8640	-.2568E 00	-.7419E 00	.5505E 00	.4464	-.1456E 05
14400.	-4.4040	-.3067E 00	-.8456E 00	.7151E 00	.5088	-.1703E 05
18000.	-4.8120	-.3525E 00	-.9240E 00	.8537E 00	.5559	-.1948E 05
21600.	-5.2160	-.4008E 00	-.1002E 01	.1003E 01	.6026	-.2157E 05
25200.	-5.5160	-.4404E 00	-.1059E 01	.1122E 01	.6372	-.2379E 05
28800.	-5.7480	-.4737E 00	-.1104E 01	.1218E 01	.6640	-.2609E 05
32400.	-6.0020	-.5134E 00	-.1152E 01	.1328E 01	.6934	-.2811E 05
36000.	-6.2080	-.5485E 00	-.1192E 01	.1421E 01	.7172	-.3020E 05
39600.	-6.2880	-.5629E 00	-.1207E 01	.1458E 01	.7264	-.3280E 05
43200.	-6.5600	-.6159E 00	-.1260E 01	.1587E 01	.7579	-.3430E 05
46800.	-6.6880	-.6433E 00	-.1284E 01	.1649E 01	.7726	-.3644E 05
50400.	-6.8160	-.6725E 00	-.1309E 01	.1713E 01	.7874	-.3851E 05
54000.	-6.9520	-.7058E 00	-.1335E 01	.1782E 01	.8031	-.4045E 05
57600.	-7.0160	-.7225E 00	-.1347E 01	.1815E 01	.8105	-.4276E 05
61200.	-7.1040	-.7464E 00	-.1364E 01	.1861E 01	.8207	-.4487E 05
64800.	-7.1880	-.7706E 00	-.1380E 01	.1905E 01	.8304	-.4695E 05
68400.	-7.2560	-.7912E 00	-.1393E 01	.1941E 01	.8383	-.4909E 05

Table ZR-9 (Continued)

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
72000.	-7.3560	-.8234E 00	-.1412E 01	.1995E 01	.8498	-.5098E 05
75600.	-7.4120	-.8425E 00	-.1423E 01	.2025E 01	.8563	-.5312E 05
79200.	-7.4880	-.8699E 00	-.1438E 01	.2067E 01	.8651	-.5508E 05
82800.	-7.5360	-.8881E 00	-.1447E 01	.2094E 01	.8706	-.5722E 05
86400.	-7.5760	-.9039E 00	-.1455E 01	.2116E 01	.8752	-.5939E 05
90000.	-7.6280	-.9253E 00	-.1465E 01	.2145E 01	.8812	-.6145E 05
93600.	-7.7280	-.9698E 00	-.1484E 01	.2202E 01	.8928	-.6308E 05
97200.	-7.8000	-.1005E 01	-.1498E 01	.2243E 01	.9011	-.6490E 05
100800.	-7.8480	-.1030E 01	-.1507E 01	.2271E 01	.9067	-.6689E 05
104400.	-7.8880	-.1052E 01	-.1515E 01	.2294E 01	.9113	-.6893E 05
108000.	-7.9440	-.1085E 01	-.1525E 01	.2327E 01	.9177	-.7080E 05
111600.	-7.9760	-.1105E 01	-.1531E 01	.2345E 01	.9214	-.7287E 05
115200.	-8.0080	-.1126E 01	-.1538E 01	.2364E 01	.9251	-.7492E 05
118800.	-8.0160	-.1131E 01	-.1539E 01	.2369E 01	.9261	-.7718E 05
122400.	-8.0880	-.1183E 01	-.1553E 01	.2412E 01	.9344	-.7882E 05
126000.	-8.1280	-.1215E 01	-.1561E 01	.2436E 01	.9390	-.8073E 05
129600.	-8.1680	-.1249E 01	-.1568E 01	.2460E 01	.9436	-.8263E 05
133200.	-8.1860	-.1265E 01	-.1572E 01	.2471E 01	.9457	-.8474E 05
136800.	-8.2160	-.1294E 01	-.1578E 01	.2489E 01	.9492	-.8672E 05
140400.	-8.2480	-.1327E 01	-.1584E 01	.2508E 01	.9529	-.8865E 05
144000.	-8.2480	-.1327E 01	-.1584E 01	.2508E 01	.9529	-.9093E 05
147600.	-8.2680	-.1348E 01	-.1588E 01	.2520E 01	.9552	-.9297E 05
151200.	-8.2800	-.1362E 01	-.1590E 01	.2528E 01	.9566	-.9510E 05
154800.	-8.2960	-.1381E 01	-.1593E 01	.2537E 01	.9584	-.9718E 05
158400.	-8.3280	-.1421E 01	-.1599E 01	.2557E 01	.9621	-.9906E 05
162000.	-8.3520	-.1454E 01	-.1604E 01	.2572E 01	.9649	-.1010E 06
165600.	-8.3680	-.1478E 01	-.1607E 01	.2582E 01	.9667	-.1031E 06
169200.	-8.4040	-.1536E 01	-.1614E 01	.2604E 01	.9709	-.1049E 06
172800.	-8.4080	-.1543E 01	-.1614E 01	.2606E 01	.9713	-.1070E 06
176400.	-8.4160	-.1557E 01	-.1616E 01	.2611E 01	.9723	-.1092E 06
180000.	-8.4400	-.1603E 01	-.1621E 01	.2626E 01	.9750	-.1111E 06
183600.	-8.4560	-.1636E 01	-.1624E 01	.2636E 01	.9769	-.1131E 06
187200.	-8.4800	-.1692E 01	-.1628E 01	.2651E 01	.9797	-.1150E 06
190800.	-8.4880	-.1712E 01	-.1630E 01	.2656E 01	.9806	-.1171E 06
194400.	-8.5040	-.1755E 01	-.1633E 01	.2666E 01	.9824	-.1191E 06
198000.	-8.5120	-.1779E 01	-.1634E 01	.2671E 01	.9834	-.1211E 06
201600.	-8.5280	-.1830E 01	-.1637E 01	.2681E 01	.9852	-.1231E 06
205200.	-8.5440	-.1888E 01	-.1641E 01	.2691E 01	.9871	-.1251E 06
208800.	-8.5600	-.1955E 01	-.1644E 01	.2702E 01	.9889	-.1270E 06
212400.	-8.5680	-.1993E 01	-.1645E 01	.2707E 01	.9898	-.1291E 06

Table ZR-9 (Continued)

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
216000.	-8.5680	-.1993E 01	-.1645E 01	.2707E 01	.9898	-.1313E 06
219600.	-8.5760	-.2034E 01	-.1647E 01	.2712E 01	.9908	-.1334E 06
223200.	-8.5840	-.2065E 01	-.1648E 01	.2717E 01	.9917	-.1354E 06
226800.	-8.5920	-.2131E 01	-.1650E 01	.2722E 01	.9926	-.1375E 06
230400.	-8.6000	-.2189E 01	-.1651E 01	.2727E 01	.9935	-.1395E 06
234000.	-8.6000	-.2189E 01	-.1651E 01	.2727E 01	.9935	-.1417E 06
237600.	-8.6000	-.2189E 01	-.1651E 01	.2727E 01	.9935	-.1439E 06
241200.	-8.6040	-.2221E 01	-.1652E 01	.2729E 01	.9940	-.1460E 06
244800.	-8.6040	-.2221E 01	-.1652E 01	.2729E 01	.9940	-.1482E 06
248400.	-8.6040	-.2221E 01	-.1652E 01	.2729E 01	.9940	-.1504E 06
252000.	-8.6080	-.2256E 01	-.1653E 01	.2732E 01	.9945	-.1525E 06
255600.	-8.6080	-.2256E 01	-.1653E 01	.2732E 01	.9945	-.1546E 06
259200.	-8.6120	-.2294E 01	-.1654E 01	.2734E 01	.9949	-.1567E 06
262800.	-8.6160	-.2335E 01	-.1654E 01	.2737E 01	.9954	-.1589E 06
266400.	-8.6160	-.2335E 01	-.1654E 01	.2737E 01	.9954	-.1610E 06
270000.	-8.6200	-.2381E 01	-.1655E 01	.2740E 01	.9958	-.1631E 06
273600.	-8.6320	-.2557E 01	-.1657E 01	.2747E 01	.9972	-.1651E 06
277200.	-8.6480	-.3034E 01	-.1661E 01	.2757E 01	.9991	-.1669E 06
280800.	-8.6520	-.3335E 01	-.1661E 01	.2760E 01	.9995	-.1690E 06

Table AL-1. Weight Losses for 2.71:1.00 Mole Ratio Al_2O_3-Nb_2O_5 Between the Oxygen Partial Pressure Range of 4.6×10^{-2} to 2.04×10^{-14} Atm. at 850°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	-.0280	-.6660E-02	-.4964E-02	.2464E-04	.0152	-.1209E 05
120.	-.0480	-.1148E-01	-.8509E-02	.7241E-04	.0261	-.1410E 05
180.	-.0680	-.1635E-01	-.1205E-01	.1453E-03	.0370	-.1493E 05
240.	-.0480	-.1148E-01	-.8509E-02	.7241E-04	.0261	-.2820E 05
300.	-.0400	-.9545E-02	-.7091E-02	.5028E-04	.0217	-.4231E 05
360.	-.0480	-.1148E-01	-.8509E-02	.7241E-04	.0261	-.4231E 05
420.	-.0840	-.2029E-01	-.1489E-01	.2217E-03	.0457	-.2820E 05
480.	-.0960	-.2327E-01	-.1702E-01	.2896E-03	.0522	-.2820E 05
540.	-.1600	-.3951E-01	-.2836E-01	.8045E-03	.0870	-.1904E 05
600.	-.1360	-.3335E-01	-.2411E-01	.5813E-03	.0739	-.2489E 05
660.	-.1600	-.3951E-01	-.2836E-01	.8045E-03	.0870	-.2327E 05
720.	-.1760	-.4366E-01	-.3120E-01	.9734E-03	.0957	-.2308E 05
780.	-.2040	-.5103E-01	-.3616E-01	.1308E-02	.1109	-.2157E 05
840.	-.2240	-.5638E-01	-.3971E-01	.1577E-02	.1217	-.2115E 05
900.	-.2440	-.6178E-01	-.4325E-01	.1871E-02	.1326	-.2081E 05
1200.	-.3960	-.1053E 00	-.7020E-01	.4928E-02	.2152	-.1709E 05
1500.	-.5200	-.1442E 00	-.9218E-01	.8498E-02	.2826	-.1627E 05
1800.	-.5320	-.1482E 00	-.9431E-01	.8894E-02	.2891	-.1909E 05
2400.	-.8280	-.2596E 00	-.1468E 00	.2155E-01	.4500	-.1635E 05
3000.	-.9280	-.3048E 00	-.1645E 00	.2706E-01	.5043	-.1824E 05
4140.	-1.0160	-.3489E 00	-.1801E 00	.3244E-01	.5522	-.2299E 05
5400.	-1.2400	-.4867E 00	-.2198E 00	.4832E-01	.6739	-.2457E 05
7200.	-1.3180	-.5471E 00	-.2336E 00	.5459E-01	.7163	-.3082E 05
10800.	-1.4480	-.6715E 00	-.2567E 00	.6589E-01	.7870	-.4207E 05
14400.	-1.5360	-.7819E 00	-.2723E 00	.7414E-01	.8348	-.5288E 05
18000.	-1.5800	-.8498E 00	-.2801E 00	.7845E-01	.8587	-.6426E 05
21600.	-1.5960	-.8774E 00	-.2829E 00	.8005E-01	.8674	-.7634E 05
25200.	-1.6040	-.8919E 00	-.2843E 00	.8085E-01	.8717	-.8862E 05
28800.	-1.5520	-.8054E 00	-.2751E 00	.7570E-01	.8435	-.1047E 06
32400.	-1.6280	-.9385E 00	-.2886E 00	.8329E-01	.8848	-.1123E 06
36000.	-1.7280	-.1216E 01	-.3063E 00	.9384E-01	.9391	-.1175E 06
39600.	-1.7400	-.1265E 01	-.3085E 00	.9515E-01	.9457	-.1284E 06
43200.	-1.7600	-.1362E 01	-.3120E 00	.9734E-01	.9565	-.1385E 06
46800.	-1.7640	-.1384E 01	-.3127E 00	.9779E-01	.9587	-.1497E 06
50400.	-1.7800	-.1487E 01	-.3155E 00	.9957E-01	.9674	-.1597E 06
54000.	-1.7960	-.1621E 01	-.3184E 00	.1014E 00	.9761	-.1696E 06
57600.	-1.7960	-.1621E 01	-.3184E 00	.1014E 00	.9761	-.1809E 06
61200.	-1.8040	-.1709E 01	-.3198E 00	.1023E 00	.9804	-.1914E 06
64800.	-1.8040	-.1709E 01	-.3198E 00	.1023E 00	.9804	-.2026E 06
68400.	-1.8280	-.2186E 01	-.3241E 00	.1050E 00	.9935	-.2111E 06
72000.	-1.8200	-.1964E 01	-.3226E 00	.1041E 00	.9891	-.2232E 06
75600.	-1.8360	-.2663E 01	-.3255E 00	.1059E 00	.9978	-.2323E 06
79200.	-1.8360	-.2663E 01	-.3255E 00	.1059E 00	.9978	-.2433E 06
82800.	-1.8360	-.2663E 01	-.3255E 00	.1059E 00	.9978	-.2544E 06
86400.	-1.8360	-.2663E 01	-.3255E 00	.1059E 00	.9978	-.2655E 06

Table AL-2. Weight Losses for 2.71:1.00 Mole Ratio Al_2O_3-Nb_2O_5 Between the Oxygen Partial Pressure Range of 2.04×10^{-14} to 3.85×10^{-17} Atm. at 850°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	-.0040	-.1043E-02	-.7091E-03	.5028E-06	.0024	-.8461E 05
120.	-.0120	-.3136E-02	-.2127E-02	.4525E-05	.0072	-.5641E 05
180.	-.0400	-.1054E-01	-.7091E-02	.5028E-04	.0240	-.2538E 05
240.	-.0680	-.1808E-01	-.1205E-01	.1453E-03	.0408	-.1991E 05
300.	-.0960	-.2574E-01	-.1702E-01	.2896E-03	.0576	-.1763E 05
360.	-.1280	-.3468E-01	-.2269E-01	.5149E-03	.0767	-.1587E 05
420.	-.1600	-.4379E-01	-.2836E-01	.8045E-03	.0959	-.1481E 05
480.	-.1920	-.5311E-01	-.3404E-01	.1158E-02	.1151	-.1410E 05
540.	-.2160	-.6023E-01	-.3829E-01	.1466E-02	.1295	-.1410E 05
600.	-.2360	-.6625E-01	-.4184E-01	.1750E-02	.1415	-.1434E 05
660.	-.2600	-.7359E-01	-.4609E-01	.2124E-02	.1559	-.1432E 05
720.	-.2920	-.8358E-01	-.5176E-01	.2679E-02	.1751	-.1391E 05
780.	-.3240	-.9380E-01	-.5744E-01	.3299E-02	.1942	-.1358E 05
840.	-.3560	-.1043E 00	-.6311E-01	.3983E-02	.2134	-.1331E 05
900.	-.3720	-.1096E 00	-.6595E-01	.4349E-02	.2230	-.1365E 05
1200.	-.4720	-.1445E 00	-.8367E-01	.7001E-02	.2830	-.1434E 05
1500.	-.5480	-.1730E 00	-.9715E-01	.9437E-02	.3285	-.1544E 05
1800.	-.6320	-.2068E 00	-.1120E 00	.1255E-01	.3789	-.1607E 05
2400.	-.7440	-.2565E 00	-.1319E 00	.1740E-01	.4460	-.1820E 05
3000.	-.8560	-.3126E 00	-.1517E 00	.2303E-01	.5132	-.1977E 05
4140.	-.9280	-.3530E 00	-.1645E 00	.2706E-01	.5564	-.2517E 05
5400.	-1.0040	-.4000E 00	-.1780E 00	.3168E-01	.6019	-.3034E 05
7200.	-1.1040	-.4709E 00	-.1957E 00	.3830E-01	.6619	-.3679E 05
10800.	-1.2160	-.5671E 00	-.2156E 00	.4647E-01	.7290	-.5010E 05
14400.	-1.2800	-.6334E 00	-.2269E 00	.5149E-01	.7674	-.6346E 05
18000.	-1.3680	-.7451E 00	-.2425E 00	.5881E-01	.8201	-.7422E 05
21600.	-1.4080	-.8072E 00	-.2496E 00	.6230E-01	.8441	-.8654E 05
25200.	-1.4400	-.8643E 00	-.2553E 00	.6516E-01	.8633	-.9872E 05
28800.	-1.4480	-.8798E 00	-.2567E 00	.6589E-01	.8681	-.1122E 06
32400.	-1.4880	-.9669E 00	-.2638E 00	.6958E-01	.8921	-.1228E 06
36000.	-1.4960	-.9867E 00	-.2652E 00	.7033E-01	.8969	-.1357E 06
39600.	-1.5200	-.1052E 01	-.2695E 00	.7261E-01	.9113	-.1470E 06
43200.	-1.5280	-.1076E 01	-.2709E 00	.7337E-01	.9161	-.1595E 06
46800.	-1.5680	-.1222E 01	-.2780E 00	.7726E-01	.9400	-.1684E 06
50400.	-1.5760	-.1258E 01	-.2794E 00	.7805E-01	.9448	-.1804E 06
54000.	-1.5760	-.1258E 01	-.2794E 00	.7805E-01	.9448	-.1933E 06
57600.	-1.5840	-.1298E 01	-.2808E 00	.7885E-01	.9496	-.2051E 06
61200.	-1.5840	-.1298E 01	-.2808E 00	.7885E-01	.9496	-.2179E 06
64800.	-1.6000	-.1390E 01	-.2836E 00	.8045E-01	.9592	-.2285E 06
68400.	-1.6080	-.1444E 01	-.2851E 00	.8126E-01	.9640	-.2400E 06

Table AL-2 (Continued)

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
72000.	-1.6240	-.1579E 01	-.2879E 00	.8288E-01	.9736	-.2501E 06
75600.	-1.6160	-.1506E 01	-.2865E 00	.8207E-01	.9688	-.2639E 06
79200.	-1.6240	-.1579E 01	-.2879E 00	.8288E-01	.9736	-.2751E 06
82800.	-1.6320	-.1666E 01	-.2893E 00	.8370E-01	.9784	-.2862E 06
86400.	-1.6400	-.1775E 01	-.2907E 00	.8452E-01	.9832	-.2972E 06
90000.	-1.6480	-.1921E 01	-.2921E 00	.8535E-01	.9880	-.3081E 06
93600.	-1.6480	-.1921E 01	-.2921E 00	.8535E-01	.9880	-.3204E 06
97200.	-1.6480	-.1921E 01	-.2921E 00	.8535E-01	.9880	-.3327E 06
100800.	-1.6480	-.1921E 01	-.2921E 00	.8535E-01	.9880	-.3450E 06
104400.	-1.6480	-.1921E 01	-.2921E 00	.8535E-01	.9880	-.3574E 06
108000.	-1.6520	-.2018E 01	-.2929E 00	.8576E-01	.9904	-.3688E 06
111600.	-1.6560	-.2143E 01	-.2936E 00	.8618E-01	.9928	-.3802E 06
115200.	-1.6560	-.2143E 01	-.2936E 00	.8618E-01	.9928	-.3924E 06
118800.	-1.6560	-.2143E 01	-.2936E 00	.8618E-01	.9928	-.4047E 06
122400.	-1.6560	-.2143E 01	-.2936E 00	.8618E-01	.9928	-.4169E 06
126000.	-1.6640	-.2620E 01	-.2950E 00	.8702E-01	.9976	-.4271E 06
129600.	-1.6640	-.2620E 01	-.2950E 00	.8702E-01	.9976	-.4393E 06

Table AL-3. Weight Losses for 2.71:1.00 Mole Ratio Al_2O_3-Nb_2O_5 Between the Oxygen Partial Pressure Range of 3.85×10^{-17} to 2.33×10^{-19} Atm. at 850°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	-.0040	-.7961E-03	-.7091E-03	.5028E-06	.0018	-.8461E 05
120.	.0040	.7947E-03	.7091E-03	.5028E-06	-.0018	.1692E 06
180.	.0000	.0000E 00	.0000E 00	.0000E 00	.0000	.1800E 03
240.	-.0040	-.7961E-03	-.7091E-03	.5028E-06	.0018	-.3385E 06
300.	-.0080	-.1594E-02	-.1418E-02	.2011E-05	.0037	-.2115E 06
360.	-.0200	-.3995E-02	-.3545E-02	.1257E-04	.0092	-.1015E 06
420.	-.0480	-.9651E-02	-.8509E-02	.7241E-04	.0220	-.4936E 05
480.	-.0800	-.1621E-01	-.1418E-01	.2011E-03	.0366	-.3385E 05
540.	-.0880	-.1786E-01	-.1560E-01	.2434E-03	.0403	-.3462E 05
600.	-.1080	-.2203E-01	-.1915E-01	.3666E-03	.0495	-.3134E 05
660.	-.1400	-.2877E-01	-.2482E-01	.6159E-03	.0641	-.2659E 05
720.	-.1520	-.3133E-01	-.2695E-01	.7261E-03	.0696	-.2672E 05
780.	-.1840	-.3822E-01	-.3262E-01	.1064E-02	.0842	-.2391E 05
840.	-.2040	-.4259E-01	-.3616E-01	.1308E-02	.0934	-.2323E 05
900.	-.2280	-.4768E-01	-.4042E-01	.1634E-02	.1044	-.2227E 05
1200.	-.3520	-.7633E-01	-.6240E-01	.3894E-02	.1612	-.1923E 05
1500.	-.4480	-.9970E-01	-.7942E-01	.6307E-02	.2051	-.1889E 05
1800.	-.5240	-.1191E 00	-.9289E-01	.8629E-02	.2399	-.1938E 05
2400.	-.6180	-.1445E 00	-.1096E 00	.1200E-01	.2830	-.2191E 05
3000.	-.7380	-.1791E 00	-.1308E 00	.1712E-01	.3379	-.2293E 05
4140.	-.8160	-.2032E 00	-.1447E 00	.2093E-01	.3736	-.2862E 05
5400.	-.9760	-.2572E 00	-.1730E 00	.2994E-01	.4469	-.3121E 05
7200.	-1.0920	-.3010E 00	-.1936E 00	.3747E-01	.5000	-.3719E 05
10800.	-1.2960	-.3908E 00	-.2297E 00	.5278E-01	.5934	-.4701E 05
14400.	-1.3960	-.4427E 00	-.2475E 00	.6124E-01	.6392	-.5819E 05
18000.	-1.4520	-.4747E 00	-.2574E 00	.6626E-01	.6648	-.6993E 05
21600.	-1.5120	-.5119E 00	-.2680E 00	.7184E-01	.6923	-.8059E 05
25200.	-1.5920	-.5669E 00	-.2822E 00	.7965E-01	.7289	-.8929E 05
28800.	-1.6320	-.5973E 00	-.2893E 00	.8370E-01	.7473	-.9955E 05
32400.	-1.6720	-.6300E 00	-.2964E 00	.8785E-01	.7656	-.1093E 06
36000.	-1.7120	-.6653E 00	-.3035E 00	.9211E-01	.7839	-.1186E 06
39600.	-1.7520	-.7038E 00	-.3106E 00	.9646E-01	.8022	-.1275E 06
43200.	-1.7800	-.7329E 00	-.3155E 00	.9957E-01	.8150	-.1369E 06
46800.	-1.8120	-.7687E 00	-.3212E 00	.1032E 00	.8297	-.1457E 06
50400.	-1.8160	-.7734E 00	-.3219E 00	.1036E 00	.8315	-.1566E 06
54000.	-1.8520	-.8181E 00	-.3283E 00	.1078E 00	.8480	-.1645E 06
57600.	-1.8720	-.8451E 00	-.3319E 00	.1101E 00	.8571	-.1736E 06
61200.	-1.8760	-.8507E 00	-.3326E 00	.1106E 00	.8590	-.1840E 06
64800.	-1.9000	-.8859E 00	-.3368E 00	.1134E 00	.8700	-.1924E 06
68400.	-1.9080	-.8983E 00	-.3382E 00	.1144E 00	.8736	-.2022E 06

Table AL-3 (Continued)

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
72000.	-1.9720	-.1013E 01	-.3496E 00	.1222E 00	.9029	-.2060E 06
75600.	-1.9800	-.1030E 01	-.3510E 00	.1232E 00	.9066	-.2154E 06
79200.	-2.0120	-.1104E 01	-.3567E 00	.1272E 00	.9212	-.2221E 06
82800.	-2.0200	-.1124E 01	-.3581E 00	.1282E 00	.9249	-.2312E 06
86400.	-2.0440	-.1193E 01	-.3623E 00	.1313E 00	.9359	-.2384E 06
90000.	-2.0520	-.1219E 01	-.3638E 00	.1323E 00	.9396	-.2474E 06
93600.	-2.1120	-.1482E 01	-.3744E 00	.1402E 00	.9670	-.2500E 06
97200.	-2.1120	-.1482E 01	-.3744E 00	.1402E 00	.9670	-.2596E 06
100800.	-2.1200	-.1533E 01	-.3758E 00	.1412E 00	.9707	-.2682E 06
104400.	-2.1320	-.1623E 01	-.3779E 00	.1428E 00	.9762	-.2762E 06
108000.	-2.1320	-.1623E 01	-.3779E 00	.1428E 00	.9762	-.2858E 06
111600.	-2.1480	-.1783E 01	-.3808E 00	.1450E 00	.9835	-.2931E 06
115200.	-2.1720	-.2260E 01	-.3850E 00	.1483E 00	.9945	-.2992E 06
118800.	-2.1800	-.2737E 01	-.3865E 00	.1493E 00	.9982	-.3074E 06

Table AL-4. Weight Losses for 2.71:1.00 Mole Ratio Al_2O_3-Nb_2O_5 Between the Oxygen Partial Pressure Range of 4.10×10^{-2} to 8.35×10^{-12} Atm. at 1000°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	-.0400	-.1137E-01	-.7091E-02	.5028E-04	.0258	-.8461E 04
120.	-.0560	-.1600E-01	-.9927E-02	.9855E-04	.0362	-.1209E 05
180.	-.0960	-.2780E-01	-.1702E-01	.2896E-03	.0620	-.1058E 05
240.	-.1200	-.3504E-01	-.2127E-01	.4525E-03	.0775	-.1128E 05
300.	-.1520	-.4489E-01	-.2695E-01	.7261E-03	.0982	-.1113E 05
360.	-.1960	-.5879E-01	-.3475E-01	.1207E-02	.1266	-.1036E 05
420.	-.2460	-.7516E-01	-.4361E-01	.1902E-02	.1589	-.9631E 04
480.	-.2550	-.7817E-01	-.4520E-01	.2043E-02	.1647	-.1062E 05
540.	-.3360	-.1063E 00	-.5956E-01	.3548E-02	.2171	-.9066E 04
600.	-.3720	-.1194E 00	-.6595E-01	.4349E-02	.2403	-.9098E 04
660.	-.4000	-.1298E 00	-.7091E-01	.5028E-02	.2584	-.9308E 04
720.	-.4240	-.1390E 00	-.7516E-01	.5650E-02	.2739	-.9579E 04
780.	-.4640	-.1547E 00	-.8225E-01	.6766E-02	.2997	-.9483E 04
840.	-.4720	-.1580E 00	-.8367E-01	.7001E-02	.3049	-.1004E 05
900.	-.5040	-.1711E 00	-.8935E-01	.7983E-02	.3256	-.1007E 05
1200.	-.6040	-.2148E 00	-.1071E 00	.1146E-01	.3902	-.1121E 05
1500.	-.6960	-.2593E 00	-.1234E 00	.1522E-01	.4496	-.1216E 05
1800.	-.7680	-.2977E 00	-.1361E 00	.1854E-01	.4961	-.1322E 05
2400.	-.8640	-.3547E 00	-.1532E 00	.2346E-01	.5581	-.1567E 05
3000.	-.9360	-.4030E 00	-.1659E 00	.2753E-01	.6047	-.1808E 05
4140.	-.9960	-.4478E 00	-.1766E 00	.3118E-01	.6434	-.2345E 05
5400.	-.9960	-.4478E 00	-.1766E 00	.3118E-01	.6434	-.3058E 05
7200.	-1.1520	-.5921E 00	-.2042E 00	.4171E-01	.7442	-.3526E 05
10800.	-1.2480	-.7126E 00	-.2212E 00	.4895E-01	.8062	-.4882E 05
14400.	-1.2760	-.7552E 00	-.2262E 00	.5117E-01	.8243	-.6366E 05
18000.	-1.3160	-.8243E 00	-.2333E 00	.5443E-01	.8501	-.7716E 05
21600.	-1.3640	-.9250E 00	-.2418E 00	.5847E-01	.8811	-.8933E 05
25200.	-1.3960	-.1008E 01	-.2475E 00	.6124E-01	.9018	-.1018E 06
28800.	-1.4200	-.1083E 01	-.2517E 00	.6337E-01	.9173	-.1144E 06
32400.	-1.4200	-.1083E 01	-.2517E 00	.6337E-01	.9173	-.1287E 06
36000.	-1.4120	-.1056E 01	-.2503E 00	.6266E-01	.9121	-.1438E 06
39600.	-1.4360	-.1141E 01	-.2546E 00	.6480E-01	.9276	-.1556E 06
43200.	-1.4520	-.1207E 01	-.2574E 00	.6626E-01	.9380	-.1678E 06
46800.	-1.4760	-.1332E 01	-.2617E 00	.6846E-01	.9535	-.1789E 06
50400.	-1.4920	-.1442E 01	-.2645E 00	.6996E-01	.9638	-.1906E 06
54000.	-1.4760	-.1332E 01	-.2617E 00	.6846E-01	.9535	-.2064E 06
57600.	-1.5080	-.1588E 01	-.2673E 00	.7146E-01	.9742	-.2155E 06
61200.	-1.5160	-.1685E 01	-.2687E 00	.7222E-01	.9793	-.2277E 06
64800.	-1.5240	-.1810E 01	-.2702E 00	.7299E-01	.9845	-.2399E 06
68400.	-1.5240	-.1810E 01	-.2702E 00	.7299E-01	.9845	-.2532E 06
72000.	-1.5320	-.1986E 01	-.2716E 00	.7376E-01	.9897	-.2651E 06
75600.	-1.5240	-.1810E 01	-.2702E 00	.7299E-01	.9845	-.2798E 06
79200.	-1.5240	-.1810E 01	-.2702E 00	.7299E-01	.9845	-.2932E 06
82800.	-1.5440	-.2588E 01	-.2737E 00	.7492E-01	.9974	-.3025E 06
86400.	-1.5440	-.2588E 01	-.2737E 00	.7492E-01	.9974	-.3157E 06

Table AL-5. Weight Losses for 2.71:1.00 Mole Ratio Al_2O_3-Nb_2O_5 Between the Oxygen Partial Pressure Range of 8.35×10^{-12} to 3.09×10^{-14} Atm. at 1000°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	-.0120	-.4409E-02	-.2127E-02	.4525E-05	.0101	-.2820E 05
120.	-.0160	-.5889E-02	-.2836E-02	.8045E-05	.0135	-.4231E 05
180.	-.0400	-.1487E-01	-.7091E-02	.5028E-04	.0337	-.2538E 05
240.	-.0600	-.2251E-01	-.1064E-01	.1131E-03	.0505	-.2256E 05
300.	-.0880	-.3342E-01	-.1560E-01	.2434E-03	.0741	-.1923E 05
360.	-.1200	-.4625E-01	-.2127E-01	.4525E-03	.1010	-.1692E 05
420.	-.1400	-.5446E-01	-.2482E-01	.6159E-03	.1178	-.1692E 05
480.	-.1560	-.6114E-01	-.2765E-01	.7648E-03	.1313	-.1736E 05
540.	-.1920	-.7656E-01	-.3404E-01	.1158E-02	.1616	-.1587E 05
600.	-.2240	-.9074E-01	-.3971E-01	.1577E-02	.1886	-.1511E 05
660.	-.2640	-.1091E 00	-.4680E-01	.2190E-02	.2222	-.1410E 05
720.	-.2880	-.1206E 00	-.5105E-01	.2607E-02	.2424	-.1410E 05
780.	-.3000	-.1264E 00	-.5318E-01	.2828E-02	.2525	-.1467E 05
840.	-.3280	-.1403E 00	-.5815E-01	.3381E-02	.2761	-.1445E 05
900.	-.3480	-.1505E 00	-.6169E-01	.3806E-02	.2929	-.1459E 05
1200.	-.4400	-.2009E 00	-.7800E-01	.6084E-02	.3704	-.1538E 05
1500.	-.5240	-.2526E 00	-.9289E-01	.8629E-02	.4411	-.1615E 05
1800.	-.5880	-.2967E 00	-.1042E 00	.1087E-01	.4949	-.1727E 05
2400.	-.6680	-.3568E 00	-.1184E 00	.1402E-01	.5623	-.2027E 05
3000.	-.7160	-.4009E 00	-.1269E 00	.1611E-01	.6027	-.2364E 05
4140.	-.7600	-.4434E 00	-.1347E 00	.1815E-01	.6397	-.3073E 05
5400.	-.8400	-.5332E 00	-.1489E 00	.2217E-01	.7071	-.3626E 05
7200.	-.9040	-.6215E 00	-.1603E 00	.2568E-01	.7609	-.4493E 05
10800.	-.9800	-.7568E 00	-.1737E 00	.3018E-01	.8249	-.6217E 05
14400.	-1.0080	-.8195E 00	-.1787E 00	.3193E-01	.8485	-.8059E 05
18000.	-1.0320	-.8817E 00	-.1829E 00	.3347E-01	.8687	-.9839E 05
21600.	-1.0320	-.8817E 00	-.1829E 00	.3347E-01	.8687	-.1161E 06
25200.	-1.0600	-.9676E 00	-.1879E 00	.3531E-01	.8923	-.1341E 06
28800.	-1.1080	-.1172E 01	-.1964E 00	.3858E-01	.9327	-.1466E 06
32400.	-1.1080	-.1172E 01	-.1964E 00	.3858E-01	.9327	-.1650E 06
36000.	-1.1320	-.1327E 01	-.2007E 00	.4027E-01	.9529	-.1794E 06
39600.	-1.1480	-.1473E 01	-.2035E 00	.4142E-01	.9663	-.1946E 06
43200.	-1.1520	-.1519E 01	-.2042E 00	.4171E-01	.9697	-.2115E 06
46800.	-1.1520	-.1519E 01	-.2042E 00	.4171E-01	.9697	-.2292E 06
50400.	-1.1480	-.1473E 01	-.2035E 00	.4142E-01	.9663	-.2477E 06
54000.	-1.1480	-.1473E 01	-.2035E 00	.4142E-01	.9663	-.2653E 06
57600.	-1.1480	-.1473E 01	-.2035E 00	.4142E-01	.9663	-.2830E 06
61200.	-1.1480	-.1473E 01	-.2035E 00	.4142E-01	.9663	-.3007E 06
64800.	-1.1480	-.1473E 01	-.2035E 00	.4142E-01	.9663	-.3184E 06
68400.	-1.1880	-.1701E 39	-.2106E 00	.4435E-01	1.0000	-.3248E 06
72000.	-1.1880	-.1701E 39	-.2106E 00	.4435E-01	1.0000	-.3419E 06

Table AL-6. Weight Losses for 2.71:1.00 Mole Ratio Al_2O_3-Nb_2O_5 Between the Oxygen Partial Pressure Range of 3.09×10^{-14} to 2.18×10^{-16} Atm. at 1000°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	.0040	.6676E-03	.7091E-03	.5028E-06	-.0015	.8461E 05
120.	.0200	.3328E-02	.3545E-02	.1257E-04	-.0077	.3385E 05
180.	.0160	.2664E-02	.2836E-02	.8045E-05	-.0062	.6346E 05
240.	.0000	.0000E 00	.0000E 00	.0000E 00	.0000	.2400E 03
300.	-.0200	-.3354E-02	-.3545E-02	.1257E-04	.0077	-.8461E 05
360.	-.0320	-.5378E-02	-.5673E-02	.3218E-04	.0123	-.6346E 05
420.	-.0560	-.9456E-02	-.9927E-02	.9855E-04	.0215	-.4231E 05
480.	-.0760	-.1288E-01	-.1347E-01	.1815E-03	.0292	-.3563E 05
540.	-.1120	-.1912E-01	-.1985E-01	.3942E-03	.0431	-.2720E 05
600.	-.1200	-.2052E-01	-.2127E-01	.4525E-03	.0462	-.2820E 05
660.	-.1480	-.2545E-01	-.2624E-01	.6884E-03	.0569	-.2516E 05
720.	-.1840	-.3188E-01	-.3262E-01	.1064E-02	.0708	-.2207E 05
780.	-.2080	-.3621E-01	-.3687E-01	.1360E-02	.0800	-.2115E 05
840.	-.2320	-.4059E-01	-.4113E-01	.1691E-02	.0892	-.2042E 05
900.	-.2320	-.4059E-01	-.4113E-01	.1691E-02	.0892	-.2188E 05
1200.	-.4120	-.7493E-01	-.7304E-01	.5334E-02	.1585	-.1643E 05
1500.	-.5160	-.9608E-01	-.9147E-01	.8367E-02	.1985	-.1640E 05
1800.	-.6200	-.1183E 00	-.1099E 00	.1208E-01	.2385	-.1638E 05
2400.	-.8160	-.1636E 00	-.1447E 00	.2093E-01	.3138	-.1659E 05
3000.	-.9440	-.1959E 00	-.1673E 00	.2800E-01	.3631	-.1793E 05
4140.	-1.0880	-.2354E 00	-.1929E 00	.3720E-01	.4185	-.2146E 05
5400.	-1.3680	-.3244E 00	-.2425E 00	.5881E-01	.5262	-.2227E 05
7200.	-1.5640	-.3996E 00	-.2773E 00	.7687E-01	.6015	-.2597E 05
10800.	-1.7840	-.5033E 00	-.3163E 00	.1000E 00	.6862	-.3415E 05
14400.	-1.9280	-.5876E 00	-.3418E 00	.1168E 00	.7415	-.4213E 05
18000.	-2.0240	-.6546E 00	-.3588E 00	.1287E 00	.7785	-.5017E 05
21600.	-2.0720	-.6923E 00	-.3673E 00	.1349E 00	.7969	-.5881E 05
25200.	-2.1440	-.7560E 00	-.3801E 00	.1445E 00	.8246	-.6630E 05
28800.	-2.2040	-.8173E 00	-.3907E 00	.1527E 00	.8477	-.7371E 05
32400.	-2.2600	-.8835E 00	-.4006E 00	.1605E 00	.8692	-.8087E 05
36000.	-2.2840	-.9153E 00	-.4049E 00	.1639E 00	.8785	-.8891E 05
39600.	-2.3560	-.1028E 01	-.4177E 00	.1744E 00	.9062	-.9481E 05
43200.	-2.3560	-.1028E 01	-.4177E 00	.1744E 00	.9062	-.1034E 06
46800.	-2.4160	-.1150E 01	-.4283E 00	.1834E 00	.9292	-.1093E 06
50400.	-2.4200	-.1160E 01	-.4290E 00	.1840E 00	.9308	-.1175E 06
54000.	-2.4600	-.1269E 01	-.4351E 00	.1902E 00	.9462	-.1238E 06
57600.	-2.4920	-.1382E 01	-.4418E 00	.1952E 00	.9585	-.1304E 06
61200.	-2.5000	-.1415E 01	-.4432E 00	.1964E 00	.9615	-.1381E 06
64800.	-2.5000	-.1415E 01	-.4432E 00	.1964E 00	.9615	-.1462E 06
68400.	-2.4960	-.1398E 01	-.4425E 00	.1958E 00	.9600	-.1546E 06

Table AL-6 (Continued)

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
72000.	-2.5160	-.1491E 01	-.4460E 00	.1989E 00	.9677	-.1614E 06
75600.	-2.5160	-.1491E 01	-.4460E 00	.1989E 00	.9677	-.1695E 06
79200.	-2.5560	-.1772E 01	-.4531E 00	.2053E 00	.9831	-.1748E 06
82800.	-2.5560	-.1772E 01	-.4531E 00	.2053E 00	.9831	-.1827E 06
86400.	-2.5640	-.1859E 01	-.4545E 00	.2066E 00	.9862	-.1901E 06
90000.	-2.5960	-.2813E 01	-.4602E 00	.2118E 00	.9985	-.1956E 06
93600.	-2.5960	-.2813E 01	-.4602E 00	.2118E 00	.9985	-.2034E 06

Table AL-7. Weight Losses for 2.71:1.00 Mole Ratio Al_2O_3-Nb_2O_5 Between the Oxygen Partial Pressure Range of 4.7×10^{-2} to 7.26×10^{-9} Atm. at 1175°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	-.0400	-.1848E-01	-.7091E-02	.5028E-04	.0417	-.8461E 04
120.	-.0520	-.2419E-01	-.9218E-02	.8498E-04	.0542	-.1302E 05
180.	-.0880	-.4175E-01	-.1560E-01	.2434E-03	.0917	-.1154E 05
240.	-.1040	-.4980E-01	-.1844E-01	.3399E-03	.1083	-.1302E 05
300.	-.1160	-.5593E-01	-.2056E-01	.4229E-03	.1208	-.1459E 05
360.	-.1280	-.6215E-01	-.2269E-01	.5149E-03	.1333	-.1587E 05
420.	-.1480	-.7272E-01	-.2624E-01	.6884E-03	.1542	-.1601E 05
480.	-.1680	-.8355E-01	-.2978E-01	.8870E-03	.1750	-.1612E 05
540.	-.1800	-.9018E-01	-.3191E-01	.1018E-02	.1875	-.1692E 05
600.	-.2120	-.1084E 00	-.3758E-01	.1412E-02	.2208	-.1597E 05
660.	-.2320	-.1201E 00	-.4113E-01	.1691E-02	.2417	-.1605E 05
720.	-.2480	-.1298E 00	-.4396E-01	.1933E-02	.2583	-.1638E 05
780.	-.2720	-.1447E 00	-.4822E-01	.2325E-02	.2833	-.1618E 05
840.	-.2840	-.1523E 00	-.5035E-01	.2535E-02	.2958	-.1668E 05
900.	-.3000	-.1627E 00	-.5318E-01	.2828E-02	.3125	-.1692E 05
1200.	-.3320	-.1843E 00	-.5885E-01	.3464E-02	.3458	-.2039E 05
1500.	-.3280	-.1816E 00	-.5815E-01	.3381E-02	.3417	-.2580E 05
1800.	-.3320	-.1843E 00	-.5885E-01	.3464E-02	.3458	-.3058E 05
2400.	-.3520	-.1984E 00	-.6240E-01	.3894E-02	.3667	-.3846E 05
3000.	-.3680	-.2099E 00	-.6524E-01	.4256E-02	.3833	-.4599E 05
4140.	-.4160	-.2467E 00	-.7375E-01	.5438E-02	.4333	-.5614E 05
5400.	-.5240	-.3428E 00	-.9289E-01	.8629E-02	.5458	-.5813E 05
7200.	-.5560	-.3759E 00	-.9856E-01	.9715E-02	.5792	-.7305E 05
10800.	-.6400	-.4771E 00	-.1135E 00	.1287E-01	.6667	-.9519E 05
14400.	-.6900	-.5509E 00	-.1223E 00	.1496E-01	.7188	-.1177E 06
18000.	-.7120	-.5878E 00	-.1262E 00	.1593E-01	.7417	-.1426E 06
21600.	-.7920	-.7570E 00	-.1404E 00	.1971E-01	.8250	-.1538E 06
25200.	-.8000	-.7782E 00	-.1418E 00	.2011E-01	.8333	-.1777E 06
28800.	-.8320	-.8751E 00	-.1475E 00	.2175E-01	.8667	-.1953E 06
32400.	-.8480	-.9331E 00	-.1503E 00	.2260E-01	.8833	-.2155E 06
36000.	-.8720	-.1038E 01	-.1546E 00	.2390E-01	.9083	-.2329E 06
39600.	-.9120	-.1301E 01	-.1617E 00	.2614E-01	.9500	-.2449E 06
43200.	-.9280	-.1477E 01	-.1645E 00	.2706E-01	.9667	-.2626E 06
46800.	-.9360	-.1602E 01	-.1659E 00	.2753E-01	.9750	-.2820E 06
50400.	-.9440	-.1778E 01	-.1673E 00	.2800E-01	.9833	-.3012E 06
54000.	-.9440	-.1778E 01	-.1673E 00	.2800E-01	.9833	-.3227E 06
57600.	-.9440	-.1778E 01	-.1673E 00	.2800E-01	.9833	-.3442E 06
61200.	-.9440	-.1778E 01	-.1673E 00	.2800E-01	.9833	-.3657E 06
64800.	-.9400	-.1681E 01	-.1666E 00	.2777E-01	.9792	-.3889E 06
68400.	-.9400	-.1681E 01	-.1666E 00	.2777E-01	.9792	-.4105E 06

Table AL-7 (Continued)

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
72000.	-.9520	-.2079E 01	-.1688E 00	.2848E-01	.9917	-.4266E 06
75600.	-.9520	-.2079E 01	-.1688E 00	.2848E-01	.9917	-.4480E 06
79200.	-.9520	-.2079E 01	-.1688E 00	.2848E-01	.9917	-.4693E 06
82800.	-.9520	-.2079E 01	-.1688E 00	.2848E-01	.9917	-.4906E 06
86400.	-.9440	-.1778E 01	-.1673E 00	.2800E-01	.9833	-.5163E 06
90000.	-.9560	-.2380E 01	-.1695E 00	.2872E-01	.9958	-.5311E 06

Table AL-8. Weight Losses for 2.71:1.00 Mole Ratio Al_2O_3-Nb_2O_5 Between the Oxygen Partial Pressure Range of 7.26×10^{-9} to 1.25×10^{-11} Atm. at 1175°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	.0040	.1294E-02	.7091E-03	.5028E-06	-.0030	.8461E 05
120.	.0000	.0000E 00	.0000E 00	.0000E 00	.0000	.1200E 03
180.	-.0080	-.2601E-02	-.1418E-02	.2011E-05	.0060	-.1269E 06
240.	-.0200	-.6531E-02	-.3545E-02	.1257E-04	.0149	-.6769E 05
300.	-.0200	-.6531E-02	-.3545E-02	.1257E-04	.0149	-.8461E 05
360.	-.0280	-.9171E-02	-.4964E-02	.2464E-04	.0209	-.7253E 05
420.	-.0320	-.1050E-01	-.5673E-02	.3218E-04	.0239	-.7404E 05
480.	-.0480	-.1564E-01	-.8509E-02	.7241E-04	.0358	-.5641E 05
540.	-.0440	-.1450E-01	-.7800E-02	.6084E-04	.0328	-.6923E 05
600.	-.0520	-.1719E-01	-.9218E-02	.8498E-04	.0388	-.6509E 05
660.	-.0600	-.1989E-01	-.1064E-01	.1131E-03	.0448	-.6205E 05
720.	-.0640	-.2125E-01	-.1135E-01	.1287E-03	.0478	-.6346E 05
780.	-.0840	-.2812E-01	-.1489E-01	.2217E-03	.0627	-.5238E 05
840.	-.0960	-.3228E-01	-.1702E-01	.2896E-03	.0716	-.4936E 05
900.	-.1040	-.3509E-01	-.1844E-01	.3399E-03	.0776	-.4882E 05
1200.	-.1640	-.5670E-01	-.2907E-01	.8452E-03	.1224	-.4128E 05
1500.	-.2120	-.7480E-01	-.3758E-01	.1412E-02	.1582	-.3991E 05
1800.	-.2600	-.9368E-01	-.4609E-01	.2124E-02	.1940	-.3905E 05
2400.	-.3600	-.1359E 00	-.6382E-01	.4073E-02	.2687	-.3761E 05
3000.	-.4200	-.1633E 00	-.7445E-01	.5544E-02	.3134	-.4029E 05
4140.	-.4880	-.1967E 00	-.8651E-01	.7484E-02	.3642	-.4786E 05
5400.	-.6320	-.2771E 00	-.1120E 00	.1255E-01	.4716	-.4820E 05
7200.	-.7080	-.3264E 00	-.1255E 00	.1575E-01	.5284	-.5737E 05
10800.	-.7840	-.3820E 00	-.1390E 00	.1932E-01	.5851	-.7771E 05
14400.	-.8440	-.4316E 00	-.1496E 00	.2239E-01	.6299	-.9624E 05
18000.	-.8880	-.4720E 00	-.1574E 00	.2478E-01	.6627	-.1143E 06
21600.	-.9280	-.5122E 00	-.1645E 00	.2706E-01	.6925	-.1313E 06
25200.	-1.0000	-.5956E 00	-.1773E 00	.3143E-01	.7463	-.1422E 06
28800.	-1.0120	-.6112E 00	-.1794E 00	.3218E-01	.7552	-.1605E 06
32400.	-1.0280	-.6330E 00	-.1822E 00	.3321E-01	.7672	-.1778E 06
36000.	-1.0680	-.6925E 00	-.1893E 00	.3585E-01	.7970	-.1901E 06
39600.	-1.0920	-.7327E 00	-.1936E 00	.3747E-01	.8149	-.2046E 06
43200.	-1.1200	-.7847E 00	-.1985E 00	.3942E-01	.8358	-.2176E 06
46800.	-1.1520	-.8529E 00	-.2042E 00	.4171E-01	.8597	-.2292E 06
50400.	-1.1760	-.9123E 00	-.2085E 00	.4346E-01	.8776	-.2418E 06
54000.	-1.1900	-.9510E 00	-.2110E 00	.4450E-01	.8881	-.2560E 06
57600.	-1.2120	-.1020E 01	-.2149E 00	.4616E-01	.9045	-.2681E 06
61200.	-1.2200	-.1048E 01	-.2163E 00	.4677E-01	.9104	-.2830E 06
64800.	-1.2040	-.9936E 00	-.2134E 00	.4556E-01	.8985	-.3036E 06
68400.	-1.1960	-.9687E 00	-.2120E 00	.4495E-01	.8925	-.3226E 06
72000.	-1.1960	-.9687E 00	-.2120E 00	.4495E-01	.8925	-.3396E 06
75600.	-1.2040	-.9936E 00	-.2134E 00	.4556E-01	.8985	-.3542E 06
79200.	-1.2040	-.9936E 00	-.2134E 00	.4556E-01	.8985	-.3711E 06
82800.	-1.2040	-.9936E 00	-.2134E 00	.4556E-01	.8985	-.3879E 06

Table A-9. Weight Losses for 2.71:1.00 Mole Ratio Al_2O_3-Nb_2O_5 Between the Oxygen Partial Pressure Range of 1.25×10^{-11} to 1.24×10^{-13} Atm. at 1175°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	-.0640	-.1200E-01	-.1135E-01	.1287E-03	.0273	-.5288E 04
120.	-.0440	-.8216E-02	-.7800E-02	.6084E-04	.0187	-.1538E 05
180.	-.0240	-.4462E-02	-.4255E-02	.1810E-04	.0102	-.4231E 05
240.	-.0120	-.2225E-02	-.2127E-02	.4525E-05	.0051	-.1128E 06
300.	-.0120	-.2225E-02	-.2127E-02	.4525E-05	.0051	-.1410E 06
360.	-.0240	-.4462E-02	-.4255E-02	.1810E-04	.0102	-.8461E 05
420.	-.0240	-.4462E-02	-.4255E-02	.1810E-04	.0102	-.9872E 05
480.	-.0280	-.5210E-02	-.4964E-02	.2464E-04	.0119	-.9670E 05
540.	-.0440	-.8216E-02	-.7800E-02	.6084E-04	.0187	-.6923E 05
600.	-.0520	-.9726E-02	-.9218E-02	.8498E-04	.0221	-.6509E 05
660.	-.0680	-.1276E-01	-.1205E-01	.1453E-03	.0290	-.5475E 05
720.	-.0760	-.1429E-01	-.1347E-01	.1815E-03	.0324	-.5344E 05
780.	-.0840	-.1582E-01	-.1489E-01	.2217E-03	.0358	-.5238E 05
840.	-.1080	-.2045E-01	-.1915E-01	.3666E-03	.0460	-.4387E 05
900.	-.1120	-.2123E-01	-.1985E-01	.3942E-03	.0477	-.4533E 05
1200.	-.1840	-.3544E-01	-.3262E-01	.1064E-02	.0784	-.3679E 05
1500.	-.2680	-.5263E-01	-.4751E-01	.2257E-02	.1141	-.3157E 05
1800.	-.3280	-.6535E-01	-.5815E-01	.3381E-02	.1397	-.3096E 05
2400.	-.4480	-.9194E-01	-.7942E-01	.6307E-02	.1908	-.3022E 05
3000.	-.5360	-.1125E 00	-.9502E-01	.9029E-02	.2283	-.3157E 05
4140.	-.6200	-.1332E 00	-.1099E 00	.1208E-01	.2641	-.3767E 05
5400.	-.8280	-.1889E 00	-.1468E 00	.2155E-01	.3526	-.3679E 05
7200.	-.9760	-.2333E 00	-.1730E 00	.2994E-01	.4157	-.4161E 05
10800.	-1.2120	-.3153E 00	-.2149E 00	.4616E-01	.5162	-.5027E 05
14400.	-1.4280	-.4069E 00	-.2531E 00	.6408E-01	.6082	-.5688E 05
18000.	-1.5440	-.4654E 00	-.2737E 00	.7492E-01	.6576	-.6576E 05
21600.	-1.6640	-.5356E 00	-.2950E 00	.8702E-01	.7087	-.7322E 05
25200.	-1.7720	-.6103E 00	-.3141E 00	.9868E-01	.7547	-.8022E 05
28800.	-1.8240	-.6514E 00	-.3233E 00	.104[illegible]E 00	.7768	-.8907E 05
32400.	-1.9040	-.7233E 00	-.3375E 00	.1139E 00	.8109	-.9599E 05
36000.	-1.9840	-.8096E 00	-.3517E 00	.1237E 00	.8450	-.1024E 06
39600.	-2.0280	-.8655E 00	-.3595E 00	.1292E 00	.8637	-.1101E 06
43200.	-2.0960	-.9693E 00	-.3716E 00	.1381E 00	.8927	-.1163E 06
46800.	-2.1520	-.1078E 01	-.3815E 00	.1455E 00	.9165	-.1227E 06
50400.	-2.1440	-.1061E 01	-.3801E 00	.1445E 00	.9131	-.1326E 06
54000.	-2.1840	-.1156E 01	-.3872E 00	.1499E 00	.9302	-.1395E 06
57600.	-2.2360	-.1321E 01	-.3964E 00	.1571E 00	.9523	-.1453E 06
61200.	-2.2640	-.1446E 01	-.4013E 00	.1611E 00	.9642	-.1525E 06
64800.	-2.2880	-.1593E 01	-.4056E 00	.1645E 00	.9744	-.1598E 06
68400.	-2.3200	-.1924E 01	-.4113E 00	.1691E 00	.9881	-.1663E 06
72000.	-2.3440	-.2769E 01	-.4155E 00	.1727E 00	.9983	-.1733E 06
75600.	-2.3440	-.2769E 01	-.4155E 00	.1727E 00	.9983	-.1819E 06
79200.	-2.3440	-.2769E 01	-.4155E 00	.1727E 00	.9983	-.1906E 06
82800.	-2.3440	-.2769E 01	-.4155E 00	.1727E 00	.9983	-.1993E 06

Table TI-1. Weight Losses for 1.67:1.00 Mole Ratio TiO_2-Nb_2O_5 Between the Oxygen Partial Pressure Range of 5.0×10^{-2} to 2.49×10^{-14} Atm. at 850°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	-.0520	-.3294E-01	-.7305E-02	.5337E-04	.0730	-.8213E 04
120.	-.0200	-.1257E-01	-.2810E-02	.7895E-05	.0281	-.4271E 05
180.	-.0560	-.3558E-01	-.7867E-02	.6190E-04	.0787	-.2288E 05
240.	-.0880	-.5730E-01	-.1236E-01	.1528E-03	.1236	-.1941E 05
300.	-.0720	-.4630E-01	-.1012E-01	.1023E-03	.1011	-.2966E 05
360.	-.0240	-.1489E-01	-.3372E-02	.1137E-04	.0337	-.1068E 06
420.	-.0840	-.5452E-01	-.1180E-01	.1393E-03	.1180	-.3559E 05
480.	-.0520	-.3294E-01	-.7305E-02	.5337E-04	.0730	-.6570E 05
540.	-.0240	-.1489E-01	-.3372E-02	.1137E-04	.0337	-.1602E 06
600.	-.1320	-.8905E-01	-.1854E-01	.3439E-03	.1854	-.3235E 05
660.	-.0240	-.1489E-01	-.3372E-02	.1137E-04	.0337	-.1957E 06
720.	-.0120	-.7382E-02	-.1686E-02	.2842E-05	.0169	-.4271E 06
780.	-.1120	-.7433E-01	-.1573E-01	.2476E-03	.1573	-.4957E 05
840.	-.0720	-.4630E-01	-.1012E-01	.1023E-03	.1011	-.8304E 05
900.	-.0420	-.2641E-01	-.5901E-02	.3482E-04	.0590	-.1525E 06
1200.	-.0360	-.2253E-01	-.5058E-02	.2558E-04	.0506	-.2373E 06
1500.	-.0440	-.2770E-01	-.6182E-02	.3821E-04	.0618	-.2427E 06
1800.	-.0300	-.1870E-01	-.4215E-02	.1776E-04	.0421	-.4271E 06
2400.	-.0520	-.3294E-01	-.7305E-02	.5337E-04	.0730	-.3285E 06
3000.	-.0760	-.4902E-01	-.1068E-01	.1140E-03	.1067	-.2810E 06
4140.	-.0960	-.6290E-01	-.1349E-01	.1819E-03	.1348	-.3070E 06
5400.	-.2200	-.1605E 00	-.3091E-01	.9553E-03	.3090	-.1747E 06
7200.	-.2960	-.2334E 00	-.4158E-01	.1729E-02	.4157	-.1731E 06
10800.	-.4600	-.4511E 00	-.6462E-01	.4176E-02	.6461	-.1671E 06
14400.	-.5080	-.5428E 00	-.7137E-01	.5093E-02	.7135	-.2018E 06
18000.	-.4960	-.5180E 00	-.6968E-01	.4856E-02	.6966	-.2583E 06
21600.	-.4960	-.5180E 00	-.6968E-01	.4856E-02	.6966	-.3100E 06
25200.	-.5480	-.6376E 00	-.7699E-01	.5927E-02	.7697	-.3273E 06
28800.	-.5360	-.6070E 00	-.7530E-01	.5670E-02	.7528	-.3825E 06
32400.	-.5520	-.6484E 00	-.7755E-01	.6014E-02	.7753	-.4176E 06
36000.	-.5760	-.7189E 00	-.8092E-01	.6548E-02	.8090	-.4449E 06
39600.	-.6040	-.8191E 00	-.8486E-01	.7200E-02	.8483	-.4667E 06
43200.	-.6160	-.8702E 00	-.8654E-01	.7489E-02	.8652	-.4992E 06
46800.	-.6280	-.9282E 00	-.8823E-01	.7784E-02	.8820	-.5304E 06
50400.	-.6320	-.9494E 00	-.8879E-01	.7883E-02	.8876	-.5676E 06
54000.	-.6400	-.9951E 00	-.8991E-01	.8084E-02	.8989	-.6006E 06
57600.	-.6240	-.9080E 00	-.8767E-01	.7685E-02	.8764	-.6570E 06
61200.	-.6320	-.9494E 00	-.8879E-01	.7883E-02	.8876	-.6893E 06
64800.	-.6030	-.8354E 00	-.8542E-01	.7296E-02	.8539	-.7586E 06
68400.	-.6160	-.8702E 00	-.8654E-01	.7489E-02	.8652	-.7904E 06
72000.	-.6160	-.8702E 00	-.8654E-01	.7489E-02	.8652	-.8320E 06
75600.	-.6320	-.9494E 00	-.8879E-01	.7883E-02	.8876	-.8515E 06
79200.	-.6560	-.1104E 01	-.9216E-01	.8494E-02	.9213	-.8594E 06
82800.	-.6760	-.1296E 01	-.9497E-01	.9019E-02	.9494	-.8718E 06
86400.	-.7080	-.2250E 01	-.9947E-01	.9894E-02	.9944	-.8686E 06

Table TI-2. Weight Losses for 1.67:1.00 Mole Ratio TiO_2-Nb_2O_5 Between the Oxygen Partial Pressure Range of 2.49×10^{-14} to 3.35×10^{-17} Atm. at 850°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	.0720	.3116E-01	.1012E-01	.1023E-03	-.0744	.5932E 04
120.	.0440	.1931E-01	.6182E-02	.3821E-04	-.0455	.1941E 05
180.	.0280	.1238E-01	.3934E-02	.1547E-04	-.0289	.4576E 05
240.	.0320	.1412E-01	.4496E-02	.2021E-04	-.0331	.5338E 05
300.	.0000	.0000E 00	.0000E 00	.0000E 00	.0000	.3000E 03
360.	-.0120	-.5417E-02	-.1686E-02	.2842E-05	.0124	-.2135E 06
420.	-.0280	-.1275E-01	-.3934E-02	.1547E-04	.0289	-.1068E 06
480.	-.0280	-.1275E-01	-.3934E-02	.1547E-04	.0289	-.1220E 06
540.	-.0440	-.2020E-01	-.6182E-02	.3821E-04	.0455	-.8736E 05
600.	-.0520	-.2398E-01	-.7305E-02	.5337E-04	.0537	-.8213E 05
660.	-.0560	-.2588E-01	-.7867E-02	.6190E-04	.0579	-.8389E 05
720.	-.0680	-.3163E-01	-.9553E-02	.9126E-04	.0702	-.7537E 05
780.	-.0800	-.3746E-01	-.1124E-01	.1263E-03	.0826	-.6940E 05
840.	-.0800	-.3746E-01	-.1124E-01	.1263E-03	.0826	-.7474E 05
900.	-.0960	-.4536E-01	-.1349E-01	.1819E-03	.0992	-.6673E 05
1200.	-.1320	-.6367E-01	-.1854E-01	.3439E-03	.1364	-.6471E 05
1500.	-.1840	-.9156E-01	-.2585E-01	.6682E-03	.1901	-.5803E 05
1800.	-.2520	-.1310E 00	-.3540E-01	.1253E-02	.2603	-.5084E 05
2400.	-.2840	-.1508E 00	-.3990E-01	.1592E-02	.2934	-.6015E 05
3000.	-.3240	-.1770E 00	-.4552E-01	.2072E-02	.3347	-.6591E 05
4140.	-.3240	-.1770E 00	-.4552E-01	.2072E-02	.3347	-.9095E 05
5400.	-.4240	-.2503E 00	-.5957E-01	.3548E-02	.4380	-.9065E 05
7200.	-.4160	-.2439E 00	-.5844E-01	.3416E-02	.4298	-.1232E 06
10800.	-.4920	-.3083E 00	-.6912E-01	.4778E-02	.5083	-.1562E 06
14400.	-.5120	-.3269E 00	-.7193E-01	.5174E-02	.5289	-.2002E 06
18000.	-.5440	-.3585E 00	-.7643E-01	.5841E-02	.5620	-.2355E 06
21600.	-.5800	-.3970E 00	-.8148E-01	.6640E-02	.5992	-.2651E 06
25200.	-.6160	-.4393E 00	-.8654E-01	.7489E-02	.6364	-.2912E 06
28800.	-.6160	-.4393E 00	-.8654E-01	.7489E-02	.6364	-.3328E 06
32400.	-.6440	-.4753E 00	-.9047E-01	.8186E-02	.6653	-.3581E 06
36000.	-.7200	-.5914E 00	-.1012E 00	.1023E-01	.7438	-.3559E 06
39600.	-.7360	-.6204E 00	-.1034E 00	.1069E-01	.7603	-.3830E 06
43200.	-.7960	-.7503E 00	-.1118E 00	.1251E-01	.8223	-.3865E 06
46800.	-.8040	-.7710E 00	-.1130E 00	.1276E-01	.8306	-.4143E 06
50400.	-.8040	-.7710E 00	-.1130E 00	.1276E-01	.8306	-.4462E 06
54000.	-.8240	-.8275E 00	-.1158E 00	.1340E-01	.8512	-.4665E 06
57600.	-.8200	-.8156E 00	-.1152E 00	.1327E-01	.8471	-.5000E 06
61200.	-.8520	-.9214E 00	-.1197E 00	.1433E-01	.8802	-.5113E 06
64800.	-.8840	-.1062E 01	-.1242E 00	.1542E-01	.9132	-.5218E 06
68400.	-.8600	-.9525E 00	-.1208E 00	.1460E-01	.8884	-.5661E 06
72000.	-.9240	-.1342E 01	-.1298E 00	.1685E-01	.9545	-.5546E 06
75600.	-.9560	-.1907E 01	-.1343E 00	.1804E-01	.9876	-.5629E 06
79200.	-.9560	-.1907E 01	-.1343E 00	.1804E-01	.9876	-.5897E 06
82800.	-.9640	-.2384E 01	-.1354E 00	.1834E-01	.9959	-.6114E 06

Astronuclear Laboratory

Table TI-3. Weight Losses for 1.67:1.00 Mole Ratio TiO_2-Nb_2O_5 Between the Oxygen Partial Pressure Range of 9.38×10^{-18} to 1.98×10^{-19} Atm. at 850°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	.3640	.1286E 00	.5114E-01	.2615E-02	-.3447	.1173E 04
120.	.4080	.1419E 00	.5732E-01	.3286E-02	-.3864	.2094E 04
180.	.4720	.1605E 00	.6631E-01	.4397E-02	-.4470	.2714E 04
240.	.4560	.1559E 00	.6406E-01	.4104E-02	-.4318	.3746E 04
300.	.4840	.1659E 00	.6800E-01	.4624E-02	-.4583	.4412E 04
360.	.4760	.1616E 00	.6687E-01	.4472E-02	-.4508	.5383E 04
420.	.4720	.1605E 00	.6631E-01	.4397E-02	-.4470	.6334E 04
480.	.5320	.1772E 00	.7474E-01	.5586E-02	-.5038	.6422E 04
540.	.5000	.1683E 00	.7024E-01	.4934E-02	-.4735	.7687E 04
600.	.4160	.1442E 00	.5844E-01	.3416E-02	-.3939	.1027E 05
660.	.4480	.1536E 00	.6294E-01	.3961E-02	-.4242	.1049E 05
720.	.4760	.1616E 00	.6687E-01	.4472E-02	-.4508	.1077E 05
780.	.5400	.1794E 00	.7586E-01	.5755E-02	-.5114	.1028E 05
840.	.5280	.1761E 00	.7418E-01	.5502E-02	-.5000	.1132E 05
900.	.5000	.1683E 00	.7024E-01	.4934E-02	-.4735	.1281E 05
1200.	.4760	.1616E 00	.6687E-01	.4472E-02	-.4508	.1794E 05
1500.	.4360	.1501E 00	.6125E-01	.3752E-02	-.4129	.2449E 05
1800.	.3520	.1249E 00	.4945E-01	.2446E-02	-.3333	.3640E 05
2400.	.1920	.7255E-01	.2697E-01	.7276E-03	-.1818	.8897E 05
3000.	.1200	.4674E-01	.1686E-01	.2842E-03	-.1136	.1779E 06
4140.	.0600	.2400E-01	.8429E-02	.7105E-04	-.0568	.4911E 06
5400.	-.1280	-.5612E-01	-.1798E-01	.3234E-03	.1212	-.3003E 06
7200.	-.2140	-.9835E-01	-.3006E-01	.9039E-03	.2027	-.2395E 06
10800.	-.2100	-.9629E-01	-.2950E-01	.8704E-03	.1989	-.3661E 06
14400.	-.5040	-.2817E 00	-.7081E-01	.5014E-02	.4773	-.2034E 06
18000.	-.4800	-.2632E 00	-.6743E-01	.4547E-02	.4545	-.2669E 06
21600.	-.5160	-.2913E 00	-.7249E-01	.5255E-02	.4886	-.2980E 06
25200.	-.5480	-.3178E 00	-.7699E-01	.5927E-02	.5189	-.3273E 06
28800.	-.5760	-.3424E 00	-.8092E-01	.6548E-02	.5455	-.3559E 06
32400.	-.6400	-.4046E 00	-.8991E-01	.8084E-02	.6061	-.3603E 06
36000.	-.6760	-.4439E 00	-.9497E-01	.9019E-02	.6402	-.3791E 06
39600.	-.6840	-.4531E 00	-.9609E-01	.9234E-02	.6477	-.4121E 06
43200.	-.6920	-.4626E 00	-.9722E-01	.9451E-02	.6553	-.4444E 06
46800.	-.7920	-.6021E 00	-.1113E 00	.1238E-01	.7500	-.4206E 06
50400.	-.8080	-.6292E 00	-.1135E 00	.1289E-01	.7652	-.4440E 06
54000.	-.8360	-.6812E 00	-.1174E 00	.1379E-01	.7917	-.4598E 06
57600.	-.8680	-.7495E 00	-.1219E 00	.1487E-01	.8220	-.4723E 06
61200.	-.8840	-.7881E 00	-.1242E 00	.1542E-01	.8371	-.4928E 06
64800.	-.9000	-.8305E 00	-.1264E 00	.1599E-01	.8523	-.5125E 06
68400.	-.9040	-.8418E 00	-.1270E 00	.1613E-01	.8561	-.5386E 06
72000.	-.9760	-.1121E 01	-.1371E 00	.1880E-01	.9242	-.5251E 06
75600.	-1.0120	-.1380E 01	-.1422E 00	.2021E-01	.9583	-.5317E 06
79200.	-1.0360	-.1725E 01	-.1455E 00	.2118E-01	.9811	-.5442E 06
82800.	-1.0520	-.2422E 01	-.1478E 00	.2184E-01	.9962	-.5602E 06

Table TI-4. Weight Losses for 1.67:1.00 Mole Ratio TiO_2-Nb_2O_5 Between the Oxygen Partial Pressure Range of 4.6×10^{-2} to 1.54×10^{-11} Atm. at 1000°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	-.0360	-.5856E-02	-.5058E-02	.2558E-04	.0134	-.1186E 05
120.	-.0680	-.1113E-01	-.9553E-02	.9126E-04	.0253	-.1256E 05
180.	-.0680	-.1113E-01	-.9553E-02	.9126E-04	.0253	-.1884E 05
240.	-.0600	-.9804E-02	-.8429E-02	.7105E-04	.0223	-.2847E 05
300.	-.0680	-.1113E-01	-.9553E-02	.9126E-04	.0253	-.3140E 05
360.	-.0720	-.1179E-01	-.1012E-01	.1023E-03	.0268	-.3559E 05
420.	-.0400	-.6511E-02	-.5620E-02	.3158E-04	.0149	-.7474E 05
480.	-.0560	-.9143E-02	-.7867E-02	.6190E-04	.0208	-.6101E 05
540.	-.0120	-.1943E-02	-.1686E-02	.2842E-05	.0045	-.3203E 06
600.	-.0400	-.6511E-02	-.5620E-02	.3158E-04	.0149	-.1068E 06
660.	-.0220	-.3569E-02	-.3091E-02	.9553E-05	.0082	-.2135E 06
720.	-.0140	-.2268E-02	-.1967E-02	.3868E-05	.0052	-.3661E 06
780.	-.0280	-.4548E-02	-.3934E-02	.1547E-04	.0104	-.1983E 06
840.	-.0080	-.1294E-02	-.1124E-02	.1263E-05	.0030	-.7474E 06
900.	-.0280	-.4548E-02	-.3934E-02	.1547E-04	.0104	-.2288E 06
1200.	-.0480	-.7825E-02	-.6743E-02	.4547E-04	.0179	-.1779E 06
1500.	-.1440	-.2391E-01	-.2023E-01	.4093E-03	.0536	-.7415E 05
1800.	-.3480	-.6021E-01	-.4889E-01	.2390E-02	.1295	-.3682E 05
2400.	-.5720	-.1039E 00	-.8036E-01	.6458E-02	.2128	-.2987E 05
3000.	-.8440	-.1637E 00	-.1186E 00	.1406E-01	.3140	-.2530E 05
4140.	-1.0080	-.2041E 00	-.1416E 00	.2005E-01	.3750	-.2923E 05
5400.	-1.2440	-.2699E 00	-.1748E 00	.3054E-01	.4628	-.3090E 05
7200.	-1.3160	-.2921E 00	-.1849E 00	.3418E-01	.4896	-.3894E 05
10800.	-1.4440	-.3346E 00	-.2029E 00	.4115E-01	.5372	-.5324E 05
14400.	-1.5800	-.3849E 00	-.2220E 00	.4927E-01	.5878	-.6487E 05
18000.	-1.6840	-.4277E 00	-.2366E 00	.5597E-01	.6265	-.7608E 05
21600.	-1.8080	-.4849E 00	-.2540E 00	.6452E-01	.6726	-.8504E 05
25200.	-1.8600	-.5114E 00	-.2613E 00	.6828E-01	.6920	-.9644E 05
28800.	-1.9560	-.5649E 00	-.2748E 00	.7551E-01	.7277	-.1048E 06
32400.	-2.0000	-.5918E 00	-.2810E 00	.7895E-01	.7440	-.1153E 06
36000.	-2.0720	-.6398E 00	-.2911E 00	.8474E-01	.7708	-.1237E 06
39600.	-2.1280	-.6812E 00	-.2990E 00	.8938E-01	.7917	-.1325E 06
43200.	-2.2040	-.7446E 00	-.3096E 00	.9588E-01	.8199	-.1395E 06
46800.	-2.2200	-.7592E 00	-.3119E 00	.9727E-01	.8259	-.1501E 06
50400.	-2.2680	-.8062E 00	-.3186E 00	.1015E 00	.8438	-.1582E 06
54000.	-2.3200	-.8636E 00	-.3259E 00	.1062E 00	.8631	-.1657E 06
57600.	-2.3560	-.9083E 00	-.3310E 00	.1096E 00	.8765	-.1740E 06
61200.	-2.4120	-.9885E 00	-.3389E 00	.1148E 00	.8973	-.1806E 06
64800.	-2.4280	-.1014E 01	-.3411E 00	.1164E 00	.9033	-.1900E 06
68400.	-2.4840	-.1120E 01	-.3490E 00	.1218E 00	.9241	-.1960E 06
72000.	-2.5240	-.1215E 01	-.3546E 00	.1257E 00	.9390	-.2030E 06
75600.	-2.5440	-.1271E 01	-.3574E 00	.1277E 00	.9464	-.2115E 06
79200.	-2.5640	-.1336E 01	-.3602E 00	.1298E 00	.9539	-.2199E 06
82800.	-2.6840	-.2827E 01	-.3771E 00	.1422E 00	.9985	-.2196E 06
86400.	-2.6920	-.2827E 01	-.3782E 00	.1430E 00	1.0015	-.2285E 06

Astronuclear Laboratory

Table TI-5. Weight Losses for 1.67:1.00 Mole Ratio TiO_2-Nb_2O_5 Between the Oxygen Partial Pressure Range of 1.54×10^{-11} to 3.36×10^{-14} Atm. at 1000°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	.0400	.5921E-02	.5620E-02	.3158E-04	-.0137	.1068E 05
120.	.0080	.1191E-02	.1124E-02	.1263E-05	-.0027	.1068E 06
180.	.0360	.5332E-02	.5058E-02	.2558E-04	-.0124	.3559E 05
240.	.0840	.1234E-01	.1180E-01	.1393E-03	-.0288	.2034E 05
300.	.1000	.1465E-01	.1405E-01	.1974E-03	-.0343	.2135E 05
360.	.0320	.4743E-02	.4496E-02	.2021E-04	-.0110	.8008E 05
420.	.0600	.8851E-02	.8429E-02	.7105E-04	-.0206	.4983E 05
480.	.0440	.6509E-02	.6182E-02	.3821E-04	-.0151	.7765E 05
540.	-.0120	-.1792E-02	-.1686E-02	.2842E-05	.0041	-.3203E 06
600.	-.0960	-.1455E-01	-.1349E-01	.1819E-03	.0329	-.4449E 05
660.	-.0720	-.1087E-01	-.1012E-01	.1023E-03	.0247	-.6525E 05
720.	-.1520	-.2327E-01	-.2135E-01	.4560E-03	.0522	-.3372E 05
780.	-.1360	-.2076E-01	-.1911E-01	.3651E-03	.0467	-.4082E 05
840.	-.1200	-.1826E-01	-.1686E-01	.2842E-03	.0412	-.4983E 05
900.	-.1320	-.2013E-01	-.1854E-01	.3439E-03	.0453	-.4853E 05
1200.	-.3280	-.5186E-01	-.4608E-01	.2123E-02	.1126	-.2604E 05
1500.	-.4320	-.6969E-01	-.6069E-01	.3683E-02	.1482	-.2472E 05
1800.	-.4880	-.7960E-01	-.6856E-01	.4700E-02	.1675	-.2625E 05
2400.	-.6400	-.1077E 00	-.8991E-01	.8084E-02	.2196	-.2669E 05
3000.	-.7840	-.1361E 00	-.1101E 00	.1213E-01	.2690	-.2724E 05
4140.	-.8880	-.1579E 00	-.1248E 00	.1556E-01	.3047	-.3319E 05
5400.	-1.0480	-.1956E 00	-.1472E 00	.2168E-01	.3596	-.3668E 05
7200.	-1.1600	-.2205E 00	-.1630E 00	.2656E-01	.3981	-.4418E 05
10800.	-1.3960	-.2832E 00	-.1961E 00	.3846E-01	.4791	-.5507E 05
14400.	-1.5480	-.3290E 00	-.2175E 00	.4730E-01	.5312	-.6621E 05
18000.	-1.6720	-.3704E 00	-.2349E 00	.5518E-01	.5738	-.7663E 05
21600.	-1.7680	-.4053E 00	-.2484E 00	.6169E-01	.6067	-.8696E 05
25200.	-1.8440	-.4351E 00	-.2591E 00	.6711E-01	.6328	-.9727E 05
28800.	-1.9160	-.4654E 00	-.2692E 00	.7246E-01	.6575	-.1070E 06
32400.	-2.0120	-.5093E 00	-.2827E 00	.7990E-01	.6905	-.1146E 06
36000.	-2.1400	-.5757E 00	-.3006E 00	.9039E-01	.7344	-.1197E 06
39600.	-2.1960	-.6084E 00	-.3085E 00	.9518E-01	.7536	-.1284E 06
43200.	-2.1960	-.6084E 00	-.3085E 00	.9518E-01	.7536	-.1400E 06
46800.	-2.1960	-.6084E 00	-.3085E 00	.9518E-01	.7536	-.1517E 06
50400.	-2.1960	-.6084E 00	-.3085E 00	.9518E-01	.7536	-.1634E 06
54000.	-2.1960	-.6084E 00	-.3085E 00	.9518E-01	.7536	-.1750E 06
57600.	-2.1960	-.6084E 00	-.3085E 00	.9518E-01	.7536	-.1867E 06
61200.	-2.1960	-.6084E 00	-.3085E 00	.9518E-01	.7536	-.1984E 06
64800.	-2.1960	-.6084E 00	-.3085E 00	.9518E-01	.7536	-.2100E 06
68400.	-2.1960	-.6084E 00	-.3085E 00	.9518E-01	.7536	-.2217E 06
72000.	-2.7560	-.1266E 01	-.3872E 00	.1499E 00	.9458	-.1860E 06
75600.	-2.8400	-.1595E 01	-.3990E 00	.1592E 00	.9746	-.1895E 06
79200.	-2.8840	-.1987E 01	-.4052E 00	.1642E 00	.9897	-.1955E 06
82800.	-2.9080	-.2666E 01	-.4085E 00	.1669E 00	.9979	-.2027E 06
86400.	-2.9100	-.2862E 01	-.4098E 00	.1671E 00	.9986	-.2113E 06

Table TI-6. Weight Losses for 1.67:1.00 Mole Ratio TiO_2-Nb_2O_5 Between the Oxygen Partial Pressure Range of 3.4×10^{-2} to 1.93×10^{-11} Atm. at 1000°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	-.0600	-.6492E-02	-.8429E-02	.7105E-04	.0148	-.7118E 04
120.	-.0640	-.6928E-02	-.8991E-02	.8084E-04	.0158	-.1335E 05
180.	-.0800	-.8678E-02	-.1124E-01	.1263E-03	.0198	-.1602E 05
240.	-.0800	-.8678E-02	-.1124E-01	.1263E-03	.0198	-.2135E 05
300.	-.0640	-.6928E-02	-.8991E-02	.8084E-04	.0158	-.3337E 05
360.	-.0720	-.7802E-02	-.1012E-01	.1023E-03	.0178	-.3559E 05
420.	-.0720	-.7802E-02	-.1012E-01	.1023E-03	.0178	-.4152E 05
480.	-.0640	-.6928E-02	-.8991E-02	.8084E-04	.0158	-.5338E 05
540.	-.0640	-.6928E-02	-.8991E-02	.8084E-04	.0158	-.6006E 05
600.	-.1600	-.1753E-01	-.2248E-01	.5053E-03	.0396	-.2669E 05
660.	-.3340	-.3744E-01	-.4692E-01	.2202E-02	.0826	-.1407E 05
720.	-.5940	-.6899E-01	-.8345E-01	.6964E-02	.1469	-.8628E 04
780.	-1.2880	-.1665E 00	-.1809E 00	.3274E-01	.3185	-.4311E 04
840.	-1.5760	-.2145E 00	-.2214E 00	.4902E-01	.3897	-.3794E 04
900.	-1.8480	-.2652E 00	-.2596E 00	.6740E-01	.4570	-.3467E 04
1200.	-2.2680	-.3574E 00	-.3186E 00	.1015E 00	.5608	-.3766E 04
1500.	-2.5320	-.4273E 00	-.3557E 00	.1265E 00	.6261	-.4217E 04
1800.	-2.6560	-.4644E 00	-.3731E 00	.1392E 00	.6568	-.4824E 04
2400.	-2.7980	-.5113E 00	-.3931E 00	.1545E 00	.6919	-.6106E 04
3000.	-2.9920	-.5848E 00	-.4203E 00	.1767E 00	.7399	-.7137E 04
4140.	-3.1160	-.6393E 00	-.4378E 00	.1916E 00	.7705	-.9457E 04
5400.	-3.1960	-.6784E 00	-.4490E 00	.2016E 00	.7903	-.1203E 05
7200.	-3.2560	-.7103E 00	-.4574E 00	.2092E 00	.8051	-.1574E 05
10800.	-3.3520	-.7667E 00	-.4709E 00	.2218E 00	.8289	-.2293E 05
14400.	-3.4080	-.8034E 00	-.4788E 00	.2292E 00	.8427	-.3006E 05
18000.	-3.5120	-.8809E 00	-.4934E 00	.2434E 00	.8684	-.3648E 05
21600.	-3.5520	-.9148E 00	-.4990E 00	.2490E 00	.8783	-.4329E 05
25200.	-3.6400	-.1000E 01	-.5114E 00	.2615E 00	.9001	-.4928E 05
28800.	-3.7200	-.1096E 01	-.5226E 00	.2731E 00	.9199	-.5511E 05
32400.	-3.7560	-.1147E 01	-.5277E 00	.2784E 00	.9288	-.6140E 05
36000.	-3.7480	-.1136E 01	-.5266E 00	.2773E 00	.9268	-.6837E 05
39600.	-3.8360	-.1289E 01	-.5389E 00	.2904E 00	.9486	-.7348E 05
43200.	-3.9080	-.1473E 01	-.5490E 00	.3014E 00	.9664	-.7868E 05
46800.	-3.9280	-.1542E 01	-.5518E 00	.3045E 00	.9713	-.8481E 05
50400.	-3.9280	-.1542E 01	-.5518E 00	.3045E 00	.9713	-.9133E 05
54000.	-4.0120	-.2102E 01	-.5636E 00	.3177E 00	.9921	-.9581E 05

Astronuclear Laboratory

Table TI-7. Weight Losses for 1.67:1.00 Mole Ratio TiO_2-Nb_2O_5 Between the Oxygen Partial Pressure Range of 1.93×10^{-11} to 2.76×10^{-14} Atm. at 1000°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	.0080	.3566E-03	.1124E-02	.1263E-05	-.0008	.5338E 05
120.	.0880	.3906E-02	.1236E-01	.1528E-03	-.0090	.9706E 04
180.	.0240	.1069E-02	.3372E-02	.1137E-04	-.0025	.5338E 05
240.	.0040	.1783E-03	.5620E-03	.3158E-06	-.0004	.4271E 06
300.	-.1320	-.5926E-02	-.1854E-01	.3439E-03	.0136	-.1618E 05
360.	-.0360	-.1608E-02	-.5058E-02	.2558E-04	.0037	-.7118E 05
420.	-.1120	-.5023E-02	-.1573E-01	.2476E-03	.0115	-.2669E 05
480.	-.3240	-.1469E-01	-.4552E-01	.2072E-02	.0333	-.1055E 05
540.	-.3600	-.1636E-01	-.5058E-01	.2558E-02	.0370	-.1068E 05
600.	-.3280	-.1488E-01	-.4608E-01	.2123E-02	.0337	-.1302E 05
660.	-.5080	-.2326E-01	-.7137E-01	.5093E-02	.0522	-.9248E 04
720.	-.5240	-.2402E-01	-.7362E-01	.5419E-02	.0538	-.9780E 04
780.	-.6160	-.2837E-01	-.8654E-01	.7489E-02	.0632	-.9013E 04
840.	-.7120	-.3297E-01	-.1000E 00	.1001E-01	.0731	-.8398E 04
900.	-.6920	-.3201E-01	-.9722E-01	.9451E-02	.0710	-.9258E 04
1200.	-1.1480	-.5446E-01	-.1613E 00	.2601E-01	.1179	-.7440E 04
1500.	-1.5360	-.7453E-01	-.2158E 00	.4657E-01	.1577	-.6951E 04
1800.	-1.9200	-.9535E-01	-.2697E 00	.7276E-01	.1971	-.6673E 04
2400.	-2.5120	-.1295E 00	-.3529E 00	.1245E 00	.2579	-.6801E 04
3000.	-2.9960	-.1596E 00	-.4209E 00	.1772E 00	.3076	-.7128E 04
4140.	-3.4000	-.1865E 00	-.4777E 00	.2282E 00	.3491	-.8667E 04
5400.	-4.1920	-.2444E 00	-.5889E 00	.3468E 00	.4304	-.9169E 04
7200.	-4.6400	-.2810E 00	-.6519E 00	.4249E 00	.4764	-.1105E 05
10800.	-5.2880	-.3400E 00	-.7429E 00	.5519E 00	.5429	-.1454E 05
14400.	-5.7480	-.3874E 00	-.8075E 00	.6521E 00	.5901	-.1763E 05
18000.	-6.2560	-.4465E 00	-.8789E 00	.7725E 00	.6423	-.2048E 05
21600.	-6.5560	-.4856E 00	-.9210E 00	.8483E 00	.6731	-.2345E 05
25200.	-6.8560	-.5286E 00	-.9632E 00	.9277E 00	.7039	-.2616E 05
28800.	-7.1360	-.5729E 00	-.1003E 01	.1005E 01	.7326	-.2873E 05
32400.	-7.3560	-.6113E 00	-.1033E 01	.1068E 01	.7552	-.3135E 05
36000.	-7.6960	-.6781E 00	-.1081E 01	.1169E 01	.7901	-.3330E 05
39600.	-7.8360	-.7069E 00	-.1101E 01	.1212E 01	.8045	-.3597E 05
43200.	-8.0360	-.7571E 00	-.1129E 01	.1275E 01	.8251	-.3827E 05
46800.	-8.2360	-.8113E 00	-.1157E 01	.1339E 01	.8456	-.4045E 05
50400.	-8.3960	-.8602E 00	-.1180E 01	.1391E 01	.8620	-.4273E 05
54000.	-8.5560	-.9152E 00	-.1202E 01	.1445E 01	.8784	-.4492E 05
57600.	-8.7360	-.9868E 00	-.1227E 01	.1506E 01	.8969	-.4693E 05
61200.	-8.9160	-.1073E 01	-.1253E 01	.1569E 01	.9154	-.4886E 05
64800.	-9.0560	-.1154E 01	-.1272E 01	.1619E 01	.9298	-.5093E 05
68400.	-9.1360	-.1208E 01	-.1284E 01	.1647E 01	.9380	-.5329E 05
72000.	-9.2160	-.1269E 01	-.1295E 01	.1676E 01	.9462	-.5561E 05
75600.	-9.3400	-.1386E 01	-.1312E 01	.1722E 01	.9589	-.5761E 05
79200.	-9.4560	-.1535E 01	-.1328E 01	.1765E 01	.9708	-.5962E 05
82800.	-9.5960	-.1830E 01	-.1348E 01	.1817E 01	.9852	-.6142E 05
86400.	-9.7360	-.3386E 01	-.1358E 01	.1871E 01	.9998	-.6317E 05

Table Ti-8. Weight Losses for 1.67:1.00 Mole Ratio TiO_2-Nb_2O_5 Between the Oxygen Partial Pressure Range of 2.76×10^{-14} to 1.68×10^{-16} at 1000°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	-.1560	-.1002E-02	-.2192E-01	.4803E-03	.0023	-.2738E 04
120.	-.2160	-.[illegible]388E-02	-.3035E-01	.9209E-03	.0032	-.3954E 04
180.	-.3120	-.2006E-02	-.4383E-01	.1921E-02	.0046	-.4107E 04
240.	-.3000	-.1929E-02	-.4215E-01	.1776E-02	.0044	-.5694E 04
300.	-.4160	-.2677E-02	-.5844E-01	.3416E-02	.0061	-.5133E 04
360.	-.4080	-.2626E-02	-.5732E-01	.3286E-02	.0060	-.6281E 04
420.	-.5080	-.3272E-02	-.7137E-01	.5093E-02	.0075	-.5885E 04
480.	-.6200	-.3996E-02	-.8710E-01	.7587E-02	.0092	-.5511E 04
540.	-.6840	-.4411E-02	-.9609E-01	.9234E-02	.0101	-.5619E 04
600.	-.7800	-.5033E-02	-.1096E 00	.1201E-01	.0115	-.5475E 04
660.	-.9840	-.6360E-02	-.1382E 00	.1911E-01	.0145	-.4774E 04
720.	-1.0400	-.6724E-02	-.1461E 00	.2135E-01	.0154	-.4928E 04
780.	-1.2080	-.7820E-02	-.1697E 00	.2880E-01	.0178	-.4596E 04
840.	-1.3680	-.8867E-02	-.1922E 00	.3694E-01	.0202	-.4371E 04
900.	-1.4400	-.9339E-02	-.2023E 00	.4093E-01	.0213	-.4449E 04
1200.	-2.3560	-.1539E-01	-.3310E 00	.1096E 00	.0348	-.3625E 04
1500.	-3.0840	-.2025E-01	-.4333E 00	.1877E 00	.0456	-.3462E 04
1800.	-4.2440	-.2812E-01	-.5962E 00	.3555E 00	.0627	-.3019E 04
2400.	-6.4600	-.4356E-01	-.9076E 00	.8237E 00	.0954	-.2644E 04
3000.	-8.8320	-.6072E-01	-.1241E 01	.1540E 01	.1305	-.2418E 04
4140.	-11.2280	-.7877E-01	-.1577E 01	.2488E 01	.1659	-.2625E 04
5400.	-18.3200	-.1371E 00	-.2574E 01	.6624E 01	.2706	-.2098E 04
7200.	-23.0600	-.1809E 00	-.3240E 01	.1050E 02	.3407	-.2222E 04
10800.	-36.2610	-.3332E 00	-.5094E 01	.2595E 02	.5357	-.2120E 04
14400.	-45.4610	-.4836E 00	-.6387E 01	.4079E 02	.6716	-.2255E 04
18000.	-52.3610	-.6450E 00	-.7356E 01	.5411E 02	.7735	-.2447E 04
21600.	-56.9610	-.8000E 00	-.8002E 01	.6404E 02	.8415	-.2699E 04
25200.	-60.0610	-.9481E 00	-.8438E 01	.7120E 02	.8873	-.2987E 04
28800.	-62.0610	-.1080E 01	-.8719E 01	.7602E 02	.9168	-.3303E 04
32400.	-63.1610	-.1175E 01	-.8873E 01	.7874E 02	.9331	-.3651E 04
36000.	-64.1610	-.1283E 01	-.9014E 01	.8125E 02	.9479	-.3994E 04
39600.	-64.8610	-.1379E 01	-.9112E 01	.8303E 02	.9582	-.4346E 04
43200.	-65.4610	-.1482E 01	-.9197E 01	.8458E 02	.9671	-.4697E 04
46800.	-64.9610	-.1395E 01	-.9126E 01	.8329E 02	.9597	-.5128E 04
50400.	-66.0610	-.1619E 01	-.9281E 01	.8613E 02	.9759	-.5431E 04
54000.	-66.5610	-.1778E 01	-.9351E 01	.8744E 02	.9833	-.5775E 04
57600.	-66.7610	-.1863E 01	-.9379E 01	.8797E 02	.9863	-.6141E 04
61200.	-66.9610	-.1968E 01	-.9407E 01	.8850E 02	.9892	-.6506E 04
64800.	-67.0610	-.2032E 01	-.9421E 01	.8876E 02	.9907	-.6878E 04
68400.	-67.1610	-.2107E 01	-.9435E 01	.8903E 02	.9922	-.7249E 04
72000.	-67.4170	-.2394E 01	-.9471E 01	.8971E 02	.9960	-.7602E 04
75600.	-67.4610	-.2471E 01	-.9478E 01	.8982E 02	.9966	-.7977E 04
79200.	-67.5090	-.2573E 01	-.9484E 01	.8995E 02	.9973	-.8351E 04
82800.	-67.6050	-.2901E 01	-.9498E 01	.9021E 02	.9987	-.8718E 04
86400.	-67.6850	-.4132E 01	-.9509E 01	.9042E 02	.9999	-.9086E 04

Table TI-9. Weight <u>Gain</u> for 1.67:1.00 Mole Ratio TiO_2-Nb_2O_5 Between the Oxygen Partial Pressure Range of 1.68×10^{-16} to 2.66×10^{-14} Atm. at 1000°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	.1040	-.7787E-03	.1461E-01	.2135E-03	.0018	.4107E 04
120.	.2240	-.1679E-02	.3147E-01	.9903E-03	.0039	.3813E 04
180.	.7120	-.5359E-02	.1000E 00	.1001E-01	.0123	.1799E 04
240.	1.5160	-.1149E-01	.2130E 00	.4536E-01	.0261	.1127E 04
300.	2.5240	-.1931E-01	.3546E 00	.1257E 00	.0435	.8460E 03
360.	3.3840	-.2608E-01	.4754E 00	.2260E 00	.0583	.7572E 03
420.	4.3520	-.3384E-01	.6114E 00	.3738E 00	.0750	.6869E 03
480.	5.1560	-.4039E-01	.7244E 00	.5247E 00	.0888	.6627E 03
540.	6.0160	-.4751E-01	.8452E 00	.7143E 00	.1036	.6389E 03
600.	6.9520	-.5540E-01	.9767E 00	.9539E 00	.1198	.6143E 03
660.	7.8960	-.6349E-01	.1109E 01	.1231E 01	.1360	.5950E 03
720.	8.9360	-.7259E-01	.1255E 01	.1576E 01	.1539	.5735E 03
780.	9.7120	-.7951E-01	.1364E 01	.1862E 01	.1673	.5717E 03
840.	10.6920	-.8841E-01	.1502E 01	.2256E 01	.1842	.5592E 03
900.	11.5920	-.9674E-01	.1629E 01	.2652E 01	.1997	.5526E 03
1200.	11.7960	-.9865E-01	.1657E 01	.2746E 01	.2032	.7241E 03
1500.	18.9080	-.1712E 00	.2656E 01	.7056E 01	.3257	.5647E 03
1800.	22.7240	-.2157E 00	.3192E 01	.1019E 02	.3914	.5638E 03
2400.	29.3320	-.3056E 00	.4121E 01	.1698E 02	.5053	.5824E 03
3000.	34.7480	-.3964E 00	.4882E 01	.2383E 02	.5986	.6145E 03
4140.	39.3480	-.4919E 00	.5528E 01	.3056E 02	.6778	.7489E 03
5400.	47.9400	-.7590E 00	.6735E 01	.4536E 02	.8258	.8018E 03
7200.	51.9320	-.9771E 00	.7296E 01	.5323E 02	.8946	.9869E 03
10800.	54.8280	-.1255E 01	.7703E 01	.5933E 02	.9445	.1402E 04
14400.	57.0440	-.1760E 01	.8014E 01	.6422E 02	.9826	.1797E 04
18000.	57.4880	-.2013E 01	.8076E 01	.6523E 02	.9903	.2229E 04
21600.	57.7960	-.2356E 01	.8120E 01	.6593E 02	.9956	.2660E 04
25200.	58.0280	-.3384E 01	.8152E 01	.6646E 02	.9996	.3091E 04
28800.	58.1800	-.2657E 01	.8174E 01	.6681E 02	1.0022	.3524E 04

Table TI-10. Weight Losses for 1.67:1.00 Mole Ratio TiO_2-Nb_2O_5 Between the Oxygen Partial Pressure Range of 4.0×10^{-2} to 7.98×10^{-9} Atm. at 1175°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	.1040	.7001E-02	.1461E-01	.2135E-03	-.0163	.4107E 04
120.	.0840	.5663E-02	.1180E-01	.1393E-03	-.0131	.1017E 05
180.	.1160	.7801E-02	.1630E-01	.2656E-03	-.0181	.1105E 05
240.	.1040	.7001E-02	.1461E-01	.2135E-03	-.0163	.1643E 05
300.	-.0080	-.5432E-03	-.1124E-02	.1263E-05	.0012	-.2669E 06
360.	.0960	.6466E-02	.1349E-01	.1819E-03	-.0150	.2669E 05
420.	.1000	.6733E-02	.1405E-01	.1974E-03	-.0156	.2990E 05
480.	.1040	.7001E-02	.1461E-01	.2135E-03	-.0163	.3285E 05
540.	.1080	.7268E-02	.1517E-01	.2302E-03	-.0169	.3559E 05
600.	.0920	.6199E-02	.1292E-01	.1671E-03	-.0144	.4642E 05
660.	.0520	.3514E-02	.7305E-02	.5337E-04	-.0081	.9034E 05
720.	.0520	.3514E-02	.7305E-02	.5337E-04	-.0081	.9856E 05
780.	.0320	.2166E-02	.4496E-02	.2021E-04	-.0050	.1735E 06
840.	.0320	.2166E-02	.4496E-02	.2021E-04	-.0050	.1868E 06
900.	.0160	.1084E-02	.2248E-02	.5053E-05	-.0025	.4004E 06
1200.	-.3000	-.2085E-01	-.4215E-01	.1776E-02	.0469	-.2847E 05
1500.	-.7800	-.5644E-01	-.1096E 00	.1201E-01	.1219	-.1369E 05
1800.	-1.4960	-.1156E 00	-.2102E 00	.4417E-01	.2338	-.8564E 04
2400.	-2.7920	-.2489E 00	-.3922E 00	.1539E 00	.4363	-.6119E 04
3000.	-3.2680	-.3104E 00	-.4591E 00	.2108E 00	.5106	-.6534E 04
4140.	-3.6080	-.3603E 00	-.5069E 00	.2569E 00	.5638	-.8168E 04
5400.	-4.2440	-.4725E 00	-.5962E 00	.3555E 00	.6631	-.9057E 04
7200.	-4.2960	-.4831E 00	-.6035E 00	.3643E 00	.6713	-.1193E 05
10800.	-4.7380	-.5855E 00	-.6656E 00	.4431E 00	.7403	-.1623E 05
14400.	-4.9940	-.6582E 00	-.7016E 00	.4922E 00	.7803	-.2052E 05
18000.	-5.2000	-.7270E 00	-.7305E 00	.5337E 00	.8125	-.2464E 05
21600.	-5.3400	-.7809E 00	-.7502E 00	.5628E 00	.8344	-.2879E 05
25200.	-5.4560	-.8312E 00	-.7665E 00	.5875E 00	.8525	-.3288E 05
28800.	-5.5580	-.8809E 00	-.7808E 00	.6097E 00	.8684	-.3688E 05
32400.	-5.6440	-.9277E 00	-.7929E 00	.6287E 00	.8819	-.4086E 05
36000.	-5.7680	-.1005E 01	-.8103E 00	.6567E 00	.9013	-.4443E 05
39600.	-5.8340	-.1053E 01	-.8196E 00	.6718E 00	.9116	-.4832E 05
43200.	-5.8920	-.1100E 01	-.8278E 00	.6852E 00	.9206	-.5219E 05
46800.	-5.9620	-.1165E 01	-.8376E 00	.7016E 00	.9316	-.5587E 05
50400.	-6.0280	-.1236E 01	-.8469E 00	.7172E 00	.9419	-.5951E 05
54000.	-6.0680	-.1285E 01	-.8525E 00	.7267E 00	.9481	-.6334E 05
57600.	-6.1240	-.1365E 01	-.8604E 00	.7402E 00	.9569	-.6695E 05
61200.	-6.2040	-.1514E 01	-.8716E 00	.7597E 00	.9694	-.7022E 05
64800.	-6.2380	-.1597E 01	-.8764E 00	.7680E 00	.9747	-.7394E 05
68400.	-6.2880	-.1757E 01	-.8834E 00	.7804E 00	.9825	-.7743E 05
72000.	-6.2600	-.1660E 01	-.8795E 00	.7735E 00	.9781	-.8187E 05
75600.	-6.2760	-.1713E 01	-.8817E 00	.7774E 00	.9806	-.8574E 05
79200.	-6.3400	-.2028E 01	-.8907E 00	.7933E 00	.9906	-.8892E 05
82800.	-6.3400	-.2028E 01	-.8907E 00	.7933E 00	.9906	-.9296E 05
86400.	-6.3960	-.3204E 01	-.8986E 00	.8074E 00	.9994	-.9615E 05

Table TI-11. Weight Losses for 1.67:1.00 Mole Ratio TiO_2-Nb_2O_5 Between the Oxygen Partial Pressure Range of 7.98×10^{-9} to 1.75×10^{-11} Atm. at 1175°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	.0800	.1685E-02	.1124E-01	.1263E-03	-.0039	.5338E 04
120.	.0000	.0000E 00	.0000E 00	.0000E 00	.0000	.1200E 03
180.	-.0860	-.1818E-02	-.1208E-01	.1460E-03	.0042	-.1490E 05
240.	-.1440	-.3049E-02	-.2023E-01	.4093E-03	.0070	-.1186E 05
300.	-.4280	-.9125E-02	-.6013E-01	.3616E-02	.0208	-.4989E 04
360.	-.6340	-.1359E-01	-.8907E-01	.7933E-02	.0308	-.4042E 04
420.	-.8660	-.1867E-01	-.1217E 00	.1480E-01	.0421	-.3452E 04
480.	-1.1080	-.2403E-01	-.1557E 00	.2423E-01	.0536	-.3084E 04
540.	-1.3500	-.2946E-01	-.1897E 00	.3597E-01	.0656	-.2847E 04
600.	-1.5400	-.3377E-01	-.2164E 00	.4681E-01	.0748	-.2773E 04
660.	-1.7500	-.3859E-01	-.2459E 00	.6044E-01	.0850	-.2685E 04
720.	-1.9060	-.4220E-01	-.2678E 00	.7170E-01	.0926	-.2689E 04
780.	-2.1060	-.4687E-01	-.2959E 00	.8754E-01	.1023	-.2636E 04
840.	-2.2860	-.5113E-01	-.3212E 00	.1031E 00	.1111	-.2616E 04
900.	-2.4860	-.5590E-01	-.3493E 00	.1220E 00	.1208	-.2577E 04
1200.	-3.3620	-.7745E-01	-.4723E 00	.2231E 00	.1633	-.2541E 04
1500.	-4.2020	-.9916E-01	-.5903E 00	.3485E 00	.2041	-.2541E 04
1800.	-4.8540	-.1168E 00	-.6819E 00	.4650E 00	.2358	-.2640E 04
2400.	-6.0140	-.1501E 00	-.8449E 00	.7139E 00	.2922	-.2841E 04
3000.	-6.9660	-.1794E 00	-.9786E 00	.9577E 00	.3384	-.3065E 04
4140.	-7.7400	-.2048E 00	-.1087E 01	.1182E 01	.3760	-.3807E 04
5400.	-9.2300	-.2584E 00	-.1297E 01	.1681E 01	.4484	-.4164E 04
7200.	-10.4620	-.3083E 00	-.1470E 01	.2160E 01	.5083	-.4899E 04
10800.	-11.6220	-.3611E 00	-.1633E 01	.2666E 01	.5646	-.6615E 04
14400.	-13.3680	-.4552E 00	-.1878E 01	.3527E 01	.6494	-.7668E 04
18000.	-14.6260	-.5384E 00	-.2055E 01	.4222E 01	.7106	-.8760E 04
21600.	-15.4100	-.5997E 00	-.2165E 01	.4687E 01	.7486	-.9977E 04
25200.	-16.2100	-.6727E 00	-.2277E 01	.5186E 01	.7875	-.1107E 05
28800.	-16.7500	-.7299E 00	-.2353E 01	.5537E 01	.8137	-.1224E 05
32400.	-17.1540	-.7782E 00	-.2410E 01	.5808E 01	.8334	-.1344E 05
36000.	-17.3140	-.7990E 00	-.2432E 01	.5917E 01	.8411	-.1480E 05
39600.	-17.5300	-.8287E 00	-.2463E 01	.6065E 01	.8516	-.1608E 05
43200.	-17.8500	-.8767E 00	-.2508E 01	.6289E 01	.8672	-.1723E 05
46800.	-18.0500	-.9097E 00	-.2536E 01	.6430E 01	.8769	-.1846E 05
50400.	-18.2300	-.9417E 00	-.2561E 01	.6559E 01	.8856	-.1968E 05
54000.	-18.5140	-.9976E 00	-.2601E 01	.6765E 01	.8994	-.2076E 05
57600.	-18.7620	-.1053E 01	-.2636E 01	.6948E 01	.9115	-.2185E 05
61200.	-19.0900	-.1139E 01	-.2682E 01	.7193E 01	.9274	-.2282E 05
64800.	-19.2180	-.1178E 01	-.2700E 01	.7290E 01	.9336	-.2400E 05
68400.	-19.5060	-.1281E 01	-.2740E 01	.7510E 01	.9476	-.2496E 05
72000.	-19.6560	-.1346E 01	-.2761E 01	.7626E 01	.9549	-.2607E 05
75600.	-19.9100	-.1485E 01	-.2797E 01	.7824E 01	.9673	-.2703E 05
79200.	-20.0820	-.1613E 01	-.2821E 01	.7960E 01	.9756	-.2807E 05
82800.	-20.1220	-.1649E 01	-.2827E 01	.7991E 01	.9776	-.2929E 05
86400.	-20.3620	-.1967E 01	-.2861E 01	.8183E 01	.9892	-.3020E 05
90000.	-20.4820	-.2305E 01	-.2877E 01	.8280E 01	.9950	-.3128E 05

Table TI-12. Weight Losses for 1.67:1.00 Mole Ratio TiO_2-Nb_2O_5 Between the Oxygen Partial Pressure Range of 1.75×10^{-11} to 8.26×10^{-14} Atm. at 1175°C

TIME-SEC	WT-LOSS	LOG(1-M(T)/Q)	M(T)/A	M(T)/A-SQR	M(T)/Q	TIME/M(T)/A
60.	.1200	.7635E-03	.1686E-01	.2842E-03	-.0018	.3559E 04
120.	.0400	.2546E-03	.5620E-02	.3158E-04	-.0006	.2135E 05
180.	-.0960	-.6118E-03	-.1349E-01	.1819E-03	.0014	-.1335E 05
240.	-.1760	-.1122E-02	-.2473E-01	.6114E-03	.0026	-.9706E 04
300.	-.4000	-.2555E-02	-.5620E-01	.3158E-02	.0059	-.5338E 04
360.	-.7120	-.4558E-02	-.1000E 00	.1001E-01	.0104	-.3599E 04
420.	-.8960	-.5743E-02	-.1259E 00	.1585E-01	.0131	-.3337E 04
480.	-1.1320	-.7269E-02	-.1590E 00	.2529E-01	.0166	-.3018E 04
540.	-1.4440	-.9294E-02	-.2029E 00	.4115E-01	.0212	-.2662E 04
600.	-1.8000	-.1162E-01	-.2529E 00	.6395E-01	.0264	-.2373E 04
660.	-2.1160	-.1369E-01	-.2973E 00	.8837E-01	.0310	-.2220E 04
720.	-2.5120	-.1630E-01	-.3529E 00	.1245E 00	.0368	-.2040E 04
780.	-2.8720	-.1869E-01	-.4035E 00	.1628E 00	.0421	-.1933E 04
840.	-3.4280	-.2240E-01	-.4816E 00	.2319E 00	.0503	-.1744E 04
900.	-3.8240	-.2506E-01	-.5372E 00	.2886E 00	.0561	-.1675E 04
1200.	-6.2440	-.4170E-01	-.8772E 00	.7695E 00	.0916	-.1368E 04
1500.	-9.3600	-.6411E-01	-.1315E 01	.1729E 01	.1372	-.1141E 04
1800.	-12.8800	-.9090E-01	-.1809E 01	.3274E 01	.1889	-.9948E 03
2400.	-21.6400	-.1658E 00	-.3040E 01	.9243E 01	.3173	-.7894E 03
3000.	-33.2000	-.2897E 00	-.4664E 01	.2176E 02	.4868	-.6432E 03
4140.	-33.2000	-.2897E 00	-.4664E 01	.2176E 02	.4868	-.8876E 03
5400.	-63.5760	-.1169E 01	-.8932E 01	.7978E 02	.9322	-.6046E 03
7200.	-67.3960	-.1929E 01	-.9468E 01	.8965E 02	.9882	-.7604E 03
10800.	-67.7960	-.2227E 01	-.9525E 01	.9072E 02	.9941	-.1134E 04
14400.	-67.6000	-.2056E 01	-.9497E 01	.9019E 02	.9912	-.1516E 04
18000.	-67.7000	-.2135E 01	-.9511E 01	.9046E 02	.9927	-.1893E 04
21600.	-67.7760	-.2206E 01	-.9522E 01	.9066E 02	.9938	-.2268E 04
25200.	-67.8800	-.2329E 01	-.9536E 01	.9094E 02	.9953	-.2643E 04
28800.	-68.0800	-.2755E 01	-.9564E 01	.9148E 02	.9982	-.3011E 04
32400.	-68.0800	-.2755E 01	-.9564E 01	.9148E 02	.9982	-.3388E 04
36000.	-68.1200	-.2931E 01	-.9570E 01	.9159E 02	.9988	-.3762E 04
39600.	-68.2000	-.1701E 39	-.9581E 01	.9180E 02	1.0000	-.4133E 04
43200.	-68.2400	-.3232E 01	-.9587E 01	.9191E 02	1.0006	-.4506E 04
46800.	-68.2400	-.3232E 01	-.9587E 01	.9191E 02	1.0006	-.4882E 04
50400.	-68.2800	-.2931E 01	-.9593E 01	.9202E 02	1.0012	-.5254E 04
54000.	-68.2800	-.2931E 01	-.9593E 01	.9202E 02	1.0012	-.5629E 04
57600.	-68.2800	-.2931E 01	-.9593E 01	.9202E 02	1.0012	-.6005E 04
61200.	-68.3200	-.2755E 01	-.9598E 01	.9213E 02	1.0018	-.6376E 04
64800.	-68.1600	-.3232E 01	-.9576E 01	.9169E 02	.9994	-.6767E 04
68400.	-68.1920	-.3931E 01	-.9580E 01	.9178E 02	.9999	-.7140E 04
72000.	-68.1520	-.3153E 01	-.9575E 01	.9167E 02	.9993	-.7520E 04
75600.	-68.1680	-.3329E 01	-.9577E 01	.9172E 02	.9995	-.7894E 04
79200.	-68.1760	-.3454E 01	-.9578E 01	.9174E 02	.9996	-.8269E 04
82800.	-68.1920	-.3931E 01	-.9580E 01	.9178E 02	.9999	-.8643E 04
86400.	-68.1920	-.3931E 01	-.9580E 01	.9178E 02	.9999	-.9019E 04